

# TPA3250 70W 立体声、130W 峰值 PurePath™ 超高清 D 类放大器（焊盘朝下）

## 1 特性

- 差分模拟输入
- 总谐波失真+噪声 (THD+N) 为 10% 时的总输出功率
  - 70W（连续功率）/8Ω，桥接负载 (BTL) 立体声配置（32V 时）
  - 130W（峰值功率）/4Ω，BTL 立体声配置（32V 时）
- 总谐波失真+噪声 (THD+N) 为 1% 时的总输出功率
  - 60W（连续功率）/8Ω，桥接负载 (BTL) 立体声配置（32V 时）
  - 105W（峰值功率）/4Ω，BTL 立体声配置（32V 时）
- 采用高级集成反馈设计，具有高速栅极驱动器错误校正功能（PurePath™超清）
  - 高达 100kHz 的单宽带，用于高清 (HD) 源的高频成分
  - 超低 THD+N: 1W/4Ω 时为 0.005%；削波时 <0.01%
  - 电源抑制比 (PSRR) 为 60dB（BTL，无输入信号）
  - （A 加权）输出噪声 < 60μV
  - （A 加权）信噪比 (SNR) > 110dB
- 多种配置可供选择：
  - 立体声、单声道、2.1 和 4xSE
- 启动和停止时无喀哒声和噼啪声
- 92% 高效 D 类操作 (8Ω)
- 12V 至 36V 宽电源电压工作范围
- 具有错误报告功能的自保护设计（包括欠压、过压、削波和短路保护）

- 采用推荐的系统设计时，符合电磁干扰 (EMI) 标准

## 2 应用

- 高端条形音箱
- 微型 Combo 系统
- 蓝光光盘™/DVD 接收器
- 有源扬声器

## 3 说明

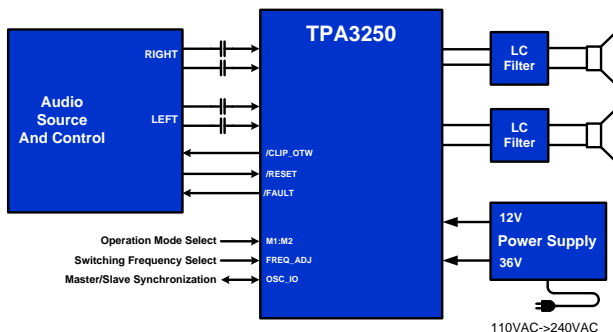
TPA3250 器件是一款高性能 D 类功率放大器，具有 D 类效率并且能够提供真正的高端音质。该器件 特有 高级集成反馈设计和专有高速栅极驱动器错误校正功能（PurePath™超高清）。该技术可使器件在整个音频频带内保持超低失真，同时展现完美音质。该器件最多可驱动 2 个 130W（峰值功率）/4Ω 负载和 2 个 70W（连续功率）/8Ω 负载，并且 特有一个 2 VRMS 模拟输入接口，支持与高性能 DAC（例如 TI 的 PCM5242）无缝连接。除了出色的音频性能外，TPA3250 还兼具高功率效率和超低功率级空闲损耗（低于 1W）两大优点。这可以通过 60mΩ MOSFET 以及优化的栅极驱动器方案来实现。该方案相对于传统的分立实现方案可显著降低空闲损耗。

### 器件信息<sup>(1)</sup>

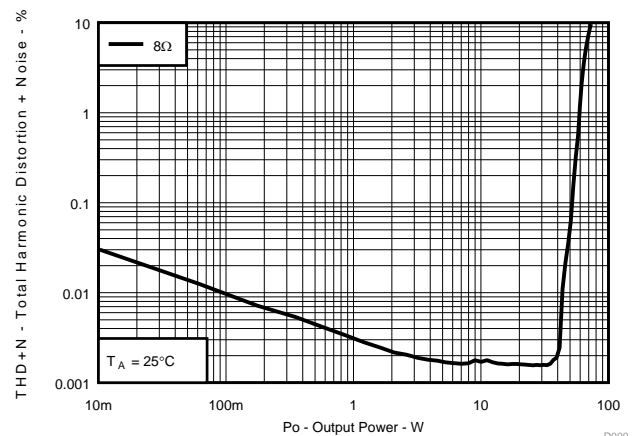
器件型号	封装	封装尺寸 (标称值)
TPA3250	HTSSOP (44)	6.10mm x 14.00mm

(1) 如需了解所有可用封装，请见数据表末尾的可订购产品附录。

简化电路原理图



总谐波失真



## 目录

<b>1</b>	特性 .....	<b>1</b>	9.2	Functional Block Diagrams .....	<b>15</b>
<b>2</b>	应用 .....	<b>1</b>	9.3	Feature Description .....	<b>17</b>
<b>3</b>	说明 .....	<b>1</b>	9.4	Device Functional Modes .....	<b>17</b>
<b>4</b>	修订历史记录 .....	<b>2</b>	<b>10</b>	<b>Application and Implementation</b> .....	<b>21</b>
<b>5</b>	<b>Device Comparison Table</b> .....	<b>3</b>	10.1	Application Information .....	<b>21</b>
<b>6</b>	<b>Pin Configuration and Functions</b> .....	<b>3</b>	10.2	Typical Applications .....	<b>21</b>
<b>7</b>	<b>Specifications</b> .....	<b>5</b>	<b>11</b>	<b>Power Supply Recommendations</b> .....	<b>28</b>
7.1	Absolute Maximum Ratings .....	<b>5</b>	11.1	Power Supplies .....	<b>28</b>
7.2	ESD Ratings .....	<b>5</b>	11.2	Powering Up .....	<b>28</b>
7.3	Recommended Operating Conditions .....	<b>6</b>	11.3	Powering Down .....	<b>29</b>
7.4	Thermal Information .....	<b>6</b>	11.4	Thermal Design .....	<b>30</b>
7.5	Electrical Characteristics .....	<b>7</b>	<b>12</b>	<b>Layout</b> .....	<b>33</b>
7.6	Audio Characteristics (BTL) .....	<b>8</b>	12.1	Layout Guidelines .....	<b>33</b>
7.7	Audio Characteristics (SE) .....	<b>9</b>	12.2	Layout Examples .....	<b>34</b>
7.8	Audio Characteristics (PBTL) .....	<b>9</b>	<b>13</b>	<b>器件和文档支持</b> .....	<b>37</b>
7.9	Typical Characteristics, BTL Configuration .....	<b>10</b>	13.1	文档支持 .....	<b>37</b>
7.10	Typical Characteristics, SE Configuration .....	<b>12</b>	13.2	社区资源 .....	<b>37</b>
7.11	Typical Characteristics, PBTL Configuration .....	<b>13</b>	13.3	商标 .....	<b>37</b>
<b>8</b>	<b>Parameter Measurement Information</b> .....	<b>14</b>	13.4	静电放电警告 .....	<b>37</b>
<b>9</b>	<b>Detailed Description</b> .....	<b>14</b>	13.5	Glossary .....	<b>37</b>
9.1	Overview .....	<b>14</b>	<b>14</b>	<b>机械、封装和可订购信息</b> .....	<b>37</b>

## 4 修订历史记录

### Changes from Original (December 2015) to Revision A

**Page**

- |  |          |
|--|----------|
| • 已将数据表器件编号由“TPS3250D2”改为“TPA3250” ..... | <b>1</b> |
|--|----------|

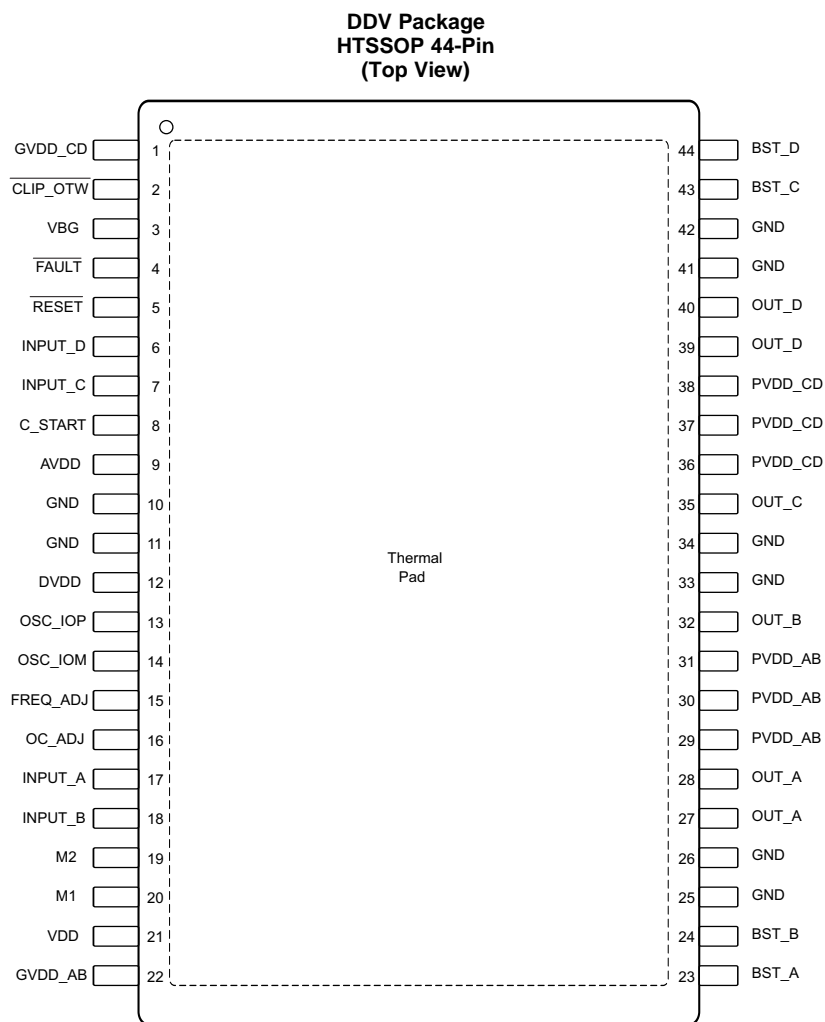
## 5 Device Comparison Table

DEVICE NAME	DESCRIPTION
TPA3251	175-W Stereo Class-D PurePath™ Ultra-HD Analog Input Audio Power Amplifier
TPA3116D2	50W Filter-Free Class-D Stereo Amplifier Family with AM Avoidance
TPA3118D2	30W Filter-Free Class-D Stereo Amplifier Family with AM Avoidance

## 6 Pin Configuration and Functions

The TPA3250 is available in a thermally enhanced TSSOP package.

The package type contains a PowerPad™ that is located on the bottom side of the device for thermal connection to the PCB.



### Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
AVDD	9	P	Internal voltage regulator, analog section
BST_A	23	P	HS bootstrap supply (BST), external 0.033 $\mu$ F capacitor to OUT_A required.
BST_B	24	P	HS bootstrap supply (BST), external 0.033 $\mu$ F capacitor to OUT_B required.
BST_C	43	P	HS bootstrap supply (BST), external 0.033 $\mu$ F capacitor to OUT_C required.
BST_D	44	P	HS bootstrap supply (BST), external 0.033 $\mu$ F capacitor to OUT_D required.
CLIP_OTW	2	O	Clipping warning and Over-temperature warning; open drain; active low
C_START	8	O	Startup ramp, requires a charging capacitor to GND
DVDD	12	P	Internal voltage regulator, digital section
FAULT	4	O	Shutdown signal, open drain; active low
FREQ_ADJ	15	O	Oscillator frequency programming pin
GND	10, 11, 25, 26, 33, 34, 41, 42	P	Ground
GVDD_AB	22	P	Gate-drive voltage supply; AB-side, requires 0.1 $\mu$ F capacitor to GND
GVDD_CD	1	P	Gate-drive voltage supply; CD-side, requires 0.1 $\mu$ F capacitor to GND
INPUT_A	17	I	Input signal for half bridge A
INPUT_B	18	I	Input signal for half bridge B
INPUT_C	7	I	Input signal for half bridge C
INPUT_D	6	I	Input signal for half bridge D
M1	20	I	Mode selection 1 (LSB)
M2	19	I	Mode selection 2 (MSB)
OC_ADJ	16	I/O	Over-Current threshold programming pin
OSC_IOM	14	I/O	Oscillator synchronization interface
OSC_IOP	13	O	Oscillator synchronization interface
OUT_A	27, 28	O	Output, half bridge A
OUT_B	32	O	Output, half bridge B
OUT_C	35	O	Output, half bridge C
OUT_D	39, 40	O	Output, half bridge D
PVDD_AB	29, 30, 31	P	PVDD supply for half-bridge A and B
PVDD_CD	36, 37, 38	P	PVDD supply for half-bridge C and D
RESET	5	I	Device reset Input; active low
VDD	21	P	Power supply for internal voltage regulator requires a 10- $\mu$ F capacitor with a 0.1- $\mu$ F capacitor to GND for decoupling.
VBG	3	P	Internal voltage reference requires a 0.1- $\mu$ F capacitor to GND for decoupling.
PowerPAD™		P	Ground, connect to PCB copper pour. Placed on bottom side of device.

**Table 1. Mode Selection Pins**

MODE PINS		INPUT MODE	OUTPUT CONFIGURATION	DESCRIPTION
M2	M1			
0	0	2N + 1	2 x BTL	Stereo BTL output configuration
0	1	2N/1N + 1	1 x BTL + 2 x SE	2.1 BTL + SE mode
1	0	2N + 1	1 x PBTL	Paralleled BTL configuration. Connect INPUT_C and INPUT_D to GND.
1	1	1N + 1	4 x SE	Single ended output configuration

## 7 Specifications

### 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

		MIN	MAX	UNIT
Supply voltage	BST_X to GVDD_X <sup>(2)</sup>	-0.3	50	V
	VDD to GND	-0.3	13.2	V
	GVDD_X to GND <sup>(2)</sup>	-0.3	13.2	V
	PVDD_X to GND <sup>(2)</sup>	-0.3	50	V
	DVDD to GND	-0.3	4.2	V
	AVDD to GND	-0.3	8.5	V
	VBG to GND	-0.3	4.2	V
Interface pins	OUT_X to GND <sup>(2)</sup>	-0.3	50	V
	BST_X to GND <sup>(2)</sup>	-0.3	62.5	V
	OC_ADJ, M1, M2, OSC_IOP, OSC_IOM, FREQ_ADJ, C_START, to GND	-0.3	4.2	V
	$\overline{\text{RESET}}$ , $\overline{\text{FAULT}}$ , $\overline{\text{CLIP\_OTW}}$ , $\overline{\text{CLIP}}$ to GND	-0.3	4.2	V
	INPUT_X to GND	-0.3	7	V
	Continuous sink current, $\overline{\text{RESET}}$ , $\overline{\text{FAULT}}$ , $\overline{\text{CLIP\_OTW}}$ , $\overline{\text{CLIP}}$ , $\overline{\text{RESET}}$ to GND		9	mA
T <sub>J</sub>	Operating junction temperature range	0	150	°C
T <sub>stg</sub>	Storage temperature range	-40	150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) These voltages represents the DC voltage + peak AC waveform measured at the terminal of the device in all conditions.

### 7.2 ESD Ratings

			VALUE	UNIT
V <sub>ESD</sub>	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup>	±500	V

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

			MIN	TYP	MAX	UNIT
PVDD_x	Half-bridge supply	DC supply voltage	12	32	38	V
GVDD_x	Supply for logic regulators and gate-drive circuitry	DC supply voltage	10.8	12	13.2	V
VDD	Digital regulator supply voltage	DC supply voltage	10.8	12	13.2	V
R <sub>L</sub> (BTL)	Load impedance	Output filter inductance within recommended value range	2.7	4		Ω
R <sub>L</sub> (SE)			1.5	3		
R <sub>L</sub> (PBTL)			1.6	2		
L <sub>OUT</sub> (BTL)	Output filter inductance	Minimum output inductance at I <sub>OC</sub>	5			μH
L <sub>OUT</sub> (SE)			5			
L <sub>OUT</sub> (PBTL)			5			
F <sub>PWM</sub>	PWM frame rate selectable for AM interference avoidance; 1% Resistor tolerance	Nominal	430	450	470	kHz
		AM1	475	500	525	
		AM2	575	600	625	
R <sub>(FREQ_ADJ)</sub>	PWM frame rate programming resistor	Nominal; Master mode	29.7	30	30.3	kΩ
		AM1; Master mode	19.8	20	20.2	
		AM2; Master mode	9.9	10	10.1	
C <sub>PVDD</sub>	PVDD close decoupling capacitors		1.0		μF	
R <sub>OC</sub>	Over-current programming resistor	Resistor tolerance = 5%	22		30	kΩ
R <sub>OC</sub> (LATCHED)	Over-current programming resistor	Resistor tolerance = 5%	47		64	kΩ
V <sub>(FREQ_ADJ)</sub>	Voltage on FREQ_ADJ pin for slave mode operation	Slave mode		3.3		V
T <sub>J</sub>	Junction temperature		0		125	°C

### 7.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TPA3250			UNIT
		DDV 44-PINS HTSSOP			
		JEDEC STANDARD 4 LAYER PCB			
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	26.0			°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	10.2			°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	6.5			°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	0.2			°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	6.5			°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	1.4			°C/W

 (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

## 7.5 Electrical Characteristics

PVDD\_X = 32 V, GVDD\_X = 12 V, VDD = 12 V, T<sub>A</sub> (Ambient temperature) = 25°C, f<sub>s</sub> = 450 kHz, unless otherwise specified.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>INTERNAL VOLTAGE REGULATOR AND CURRENT CONSUMPTION</b>						
DVDD	Voltage regulator, only used as reference node	VDD = 12 V	3	3.3	3.6	V
AVDD	Voltage regulator, only used as reference node	VDD = 12 V		7.8		V
I <sub>VDD</sub>	VDD supply current	Operating, 50% duty cycle		40		mA
		Idle, reset mode		13		
I <sub>GVDD_X</sub>	Gate-supply current per full-bridge	50% duty cycle		25		mA
		Reset mode		3		
I <sub>PVDD_X</sub>	PVDD idle current per full bridge	50% duty cycle with 10µH Output Filter Inductors		12.5		mA
		Reset mode, No switching		1		
<b>ANALOG INPUTS</b>						
R <sub>IN</sub>	Input resistance			24		kΩ
V <sub>IN</sub>	Maximum input voltage swing				7	V
I <sub>IN</sub>	Maximum input current				1	mA
G	Inverting voltage Gain	V <sub>OUT</sub> /V <sub>IN</sub>		20		dB
<b>OSCILLATOR</b>						
f <sub>OSC(I0+)</sub>	Nominal, Master Mode	F <sub>PWM</sub> × 6	2.58	2.7	2.82	MHz
	AM1, Master Mode		2.85	3	3.15	
	AM2, Master Mode		3.45	3.6	3.75	
V <sub>IH</sub>	High level input voltage		1.86			V
V <sub>IL</sub>	Low level input voltage				1.45	V
<b>OUTPUT-STAGE MOSFETS</b>						
R <sub>DS(on)</sub>	Drain-to-source resistance, low side (LS)	T <sub>J</sub> = 25°C, Includes metallization resistance, GVDD = 12 V		60	100	mΩ
	Drain-to-source resistance, high side (HS)			60	100	
<b>I/O PROTECTION</b>						
V <sub>uvp,VDD,GVDD</sub>	Undervoltage protection limit, GVDD_x and VDD			9.5		V
V <sub>uvp,VDD, GVDD,hyst</sub> <sup>(1)</sup>				0.6		V
OTW	Overtemperature warning, $\overline{\text{CLIP\_OTW}}$ <sup>(1)</sup>		115	125	135	°C
OTW <sub>hyst</sub> <sup>(1)</sup>	Temperature drop needed below OTW temperature for $\overline{\text{CLIP\_OTW}}$ to be inactive after OTW event.			25		°C
OTE <sup>(1)</sup>	Overtemperature error		145	155	165	°C
OTE-OTW <sub>(differential)</sub> <sup>(1)</sup>	OTE-OTW differential			30		°C
OTE <sub>hyst</sub> <sup>(1)</sup>	A reset needs to occur for $\overline{\text{FAULT}}$ to be released following an OTE event			25		°C
OLPC	Overload protection counter	f <sub>PWM</sub> = 450 kHz		2.3		ms
I <sub>OC</sub>	Overcurrent limit protection	Resistor – programmable, nominal peak current in 1Ω load, R <sub>OCP</sub> = 22 kΩ		14		A
I <sub>OC(LATCHED)</sub>	Overcurrent limit protection	Resistor – programmable, peak current in 1Ω load, R <sub>OCP</sub> = 47kΩ		14		A
I <sub>DCspkr</sub>	DC Speaker Protection Current Threshold	BTL current imbalance threshold		1.5		A
I <sub>OCT</sub>	Overcurrent response time	Time from switching transition to flip-state induced by overcurrent.		150		ns
I <sub>PD</sub>	Output pulldown current of each half	Connected when $\overline{\text{RESET}}$ is active to provide bootstrap charge. Not used in SE mode.		3		mA

(1) Specified by design.

## Electrical Characteristics (continued)

PVDD\_X = 32 V, GVDD\_X = 12 V, VDD = 12 V, T<sub>A</sub> (Ambient temperature) = 25°C, f<sub>S</sub> = 450 kHz, unless otherwise specified.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>STATIC DIGITAL SPECIFICATIONS</b>						
V <sub>IH</sub>	High level input voltage	M1, M2, OSC_IOP, OSC_IOM, RESET	1.9			V
V <sub>IL</sub>	Low level input voltage					0.8
I <sub>ikg</sub>	Input leakage current			100		μA
<b>OTW/SHUTDOWN (FAULT)</b>						
R <sub>INT_PU</sub>	Internal pullup resistance, CLIP_OTW to DVDD, FAULT to DVDD		20	26	32	kΩ
V <sub>OH</sub>	High level output voltage	Internal pullup resistor	3	3.3	3.6	V
V <sub>OL</sub>	Low level output voltage	I <sub>O</sub> = 4 mA		200	500	mV
Device fanout	CLIP_OTW, FAULT	No external pullup		30		devices

## 7.6 Audio Characteristics (BTL)

PCB and system configuration are in accordance with recommended guidelines. Audio frequency = 1 kHz, PVDD\_X = 32 V, GVDD\_X = 12 V, R<sub>L</sub> = 8 Ω, f<sub>S</sub> = 450 kHz, R<sub>OC</sub> = 22 kΩ, T<sub>A</sub> = 25°C, Output Filter: L<sub>DEM</sub> = 10 μH, C<sub>DEM</sub> = 1 μF, mode = 00, AES17 + AUX-0025 measurement filters, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT		
P <sub>O</sub>	Power output per channel	R <sub>L</sub> = 8 Ω, 10% THD+N		70		W		
		R <sub>L</sub> = 4 Ω, 10% THD+N, 3 seconds Peak Power <sup>(1)</sup>		130				
		R <sub>L</sub> = 4 Ω, 10% THD+N, Single Channel, 300 seconds duration <sup>(1)</sup>		130				
				R <sub>L</sub> = 8 Ω, 1% THD+N		60		
				R <sub>L</sub> = 4 Ω, 1% THD+N		40		
				R <sub>L</sub> = 4 Ω, 1% THD+N, 6 seconds Peak Power <sup>(1)</sup>		105		
				R <sub>L</sub> = 4 Ω, 1% THD+N, Single Channel <sup>(1)</sup>		105		
THD+N	Total harmonic distortion + noise	1 W		0.005%				
V <sub>n</sub>	Output integrated noise	A-weighted, AES17 filter, Input Capacitor Grounded		60		μV		
V <sub>OS</sub>	Output offset voltage	Inputs AC coupled to GND		20	60	mV		
SNR	Signal-to-noise ratio <sup>(2)</sup>			112		dB		
DNR	Dynamic range			112		dB		
P <sub>idle</sub>	Power dissipation due to Idle losses (I <sub>PVDD_X</sub> )	P <sub>O</sub> = 0, 4 channels switching <sup>(3)</sup>		0.6		W		

(1) Peak Power rating using TPA3250 EVM

(2) SNR is calculated relative to 1% THD+N output level.

(3) Actual system idle losses also are affected by core losses of output inductors.



## 7.7 Audio Characteristics (SE)

PCB and system configuration are in accordance with recommended guidelines. Audio frequency = 1 kHz, PVDD\_X = 32 V, GVDD\_X = 12 V, R<sub>L</sub> = 4 Ω, f<sub>S</sub> = 450 kHz, R<sub>OC</sub> = 22 kΩ, T<sub>A</sub> = 25°C, Output Filter: L<sub>DEM</sub> = 15 μH, C<sub>DEM</sub> = 1 μF, MODE = 11, AES17 + AUX-0025 measurement filters, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
P <sub>O</sub>	Power output per channel	R <sub>L</sub> = 4 Ω, 10% THD+N		33		W
		R <sub>L</sub> = 3 Ω, 10% THD+N		42		
		R <sub>L</sub> = 4 Ω, 1% THD+N		27		
		R <sub>L</sub> = 3 Ω, 1% THD+N		34		
THD+N	Total harmonic distortion + noise	1 W		0.015%		
V <sub>n</sub>	Output integrated noise	A-weighted, AES17 filter, Input Capacitor Grounded		111		μV
SNR	Signal to noise ratio <sup>(1)</sup>	A-weighted		100		dB
DNR	Dynamic range	A-weighted		100		dB
P <sub>idle</sub>	Power dissipation due to idle losses (IPVDD_X)	P <sub>O</sub> = 0, 4 channels switching <sup>(2)</sup>		0.5		W

(1) SNR is calculated relative to 1% THD+N output level.

(2) Actual system idle losses are affected by core losses of output inductors.

## 7.8 Audio Characteristics (PBTL)

PCB and system configuration are in accordance with recommended guidelines. Audio frequency = 1 kHz, PVDD\_X = 32 V, GVDD\_X = 12 V, R<sub>L</sub> = 4 Ω, f<sub>S</sub> = 450 kHz, R<sub>OC</sub> = 22 kΩ, T<sub>A</sub> = 25°C, Output Filter: L<sub>DEM</sub> = 10 μH, C<sub>DEM</sub> = 1 μF, MODE = 10, AES17 + AUX-0025 measurement filters, unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
P <sub>O</sub>	Power output per channel	R <sub>L</sub> = 8 Ω, 10% THD+N		75		W
		R <sub>L</sub> = 4 Ω, 10% THD+N		145		
		R <sub>L</sub> = 3 Ω, 10% THD+N		189		
		R <sub>L</sub> = 8 Ω, 1% THD+N		60		
		R <sub>L</sub> = 4 Ω, 1% THD+N		115		
		R <sub>L</sub> = 3 Ω, 1% THD+N		150		
THD+N	Total harmonic distortion + noise	1 W		0.015%		
V <sub>n</sub>	Output integrated noise	A-weighted, AES17 filter, Input Capacitor Grounded		62		μV
SNR	Signal to noise ratio <sup>(1)</sup>	A-weighted		112		dB
DNR	Dynamic range	A-weighted		107		dB
P <sub>idle</sub>	Power dissipation due to idle losses (IPVDD_X)	P <sub>O</sub> = 0, 4 channels switching <sup>(2)</sup>		0.6		W

(1) SNR is calculated relative to 1% THD+N output level.

(2) Actual system idle losses are affected by core losses of output inductors.

### 7.9 Typical Characteristics, BTL Configuration

All Measurements taken at audio frequency = 1 kHz, PVDD\_X = 32 V, GVDD\_X = 12 V, R<sub>L</sub> = 8 Ω, f<sub>S</sub> = 450 kHz, R<sub>OC</sub> = 22 kΩ, T<sub>A</sub> = 25°C, Output Filter: L<sub>DEM</sub> = 10 μH, C<sub>DEM</sub> = 1 μF, mode = 00, AES17 + AUX-0025 measurement filters, unless otherwise noted.

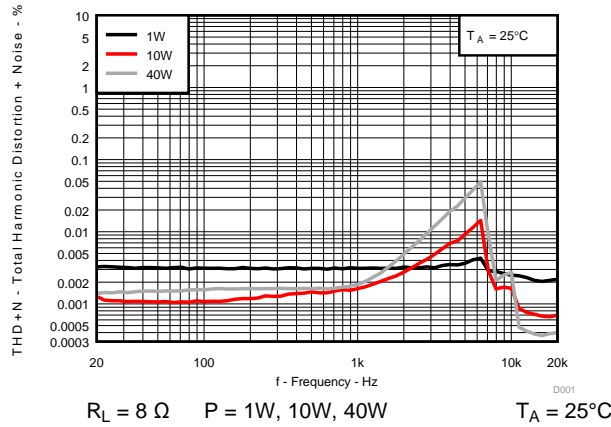


Figure 1. Total Harmonic Distortion+Noise vs Frequency

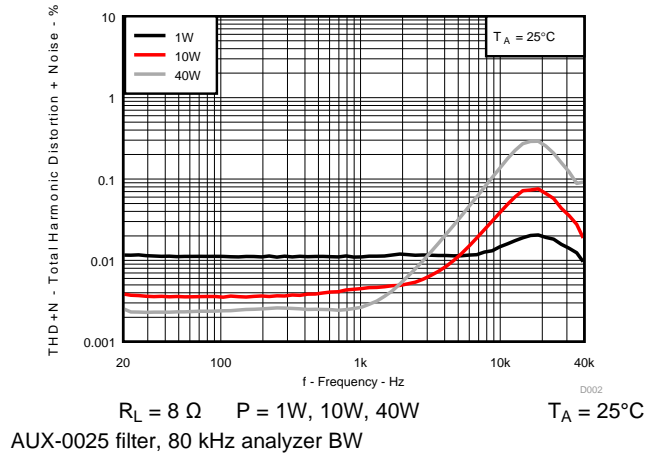


Figure 2. Total Harmonic Distortion+Noise vs Frequency

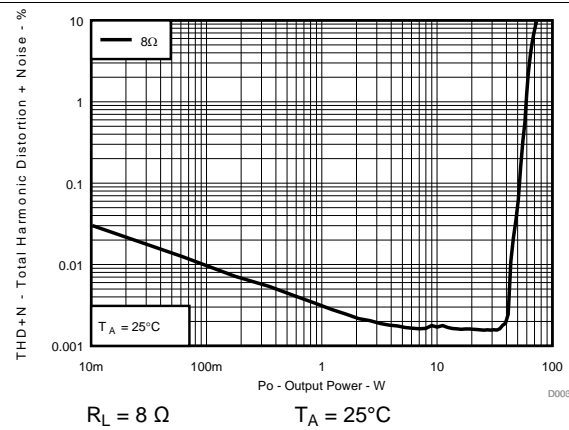


Figure 3. Total Harmonic Distortion + Noise vs Output Power

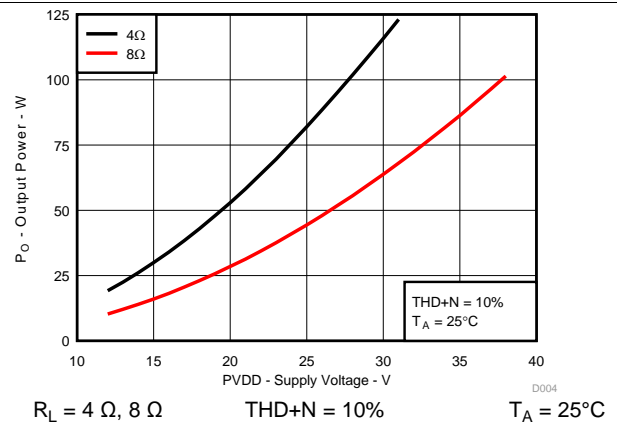


Figure 4. Output Power vs Supply Voltage

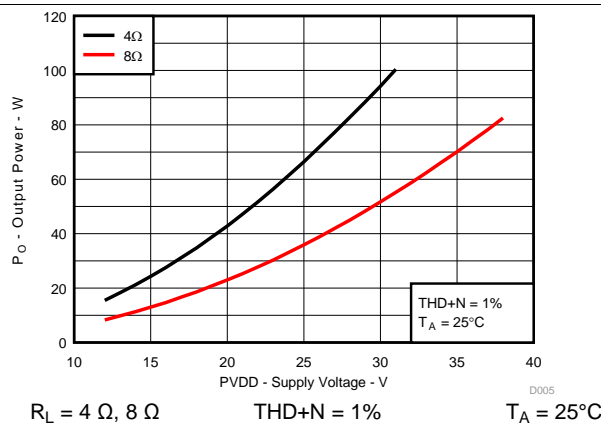


Figure 5. Output Power vs Supply Voltage

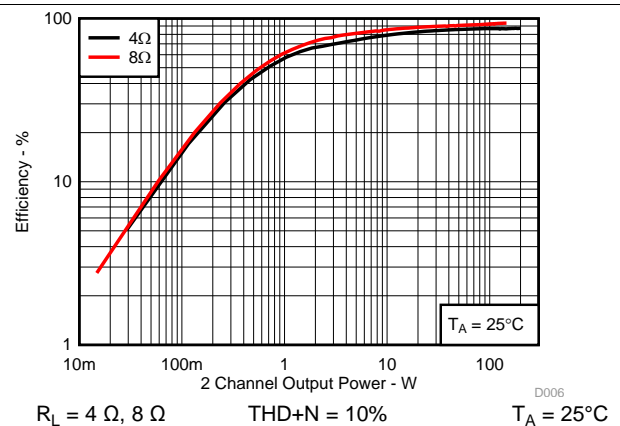
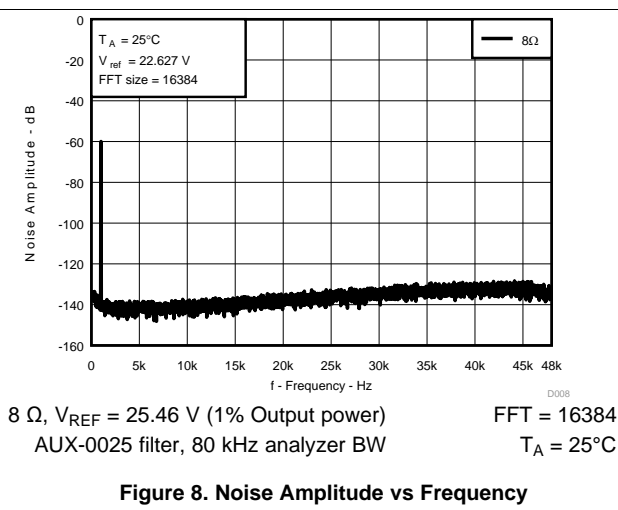
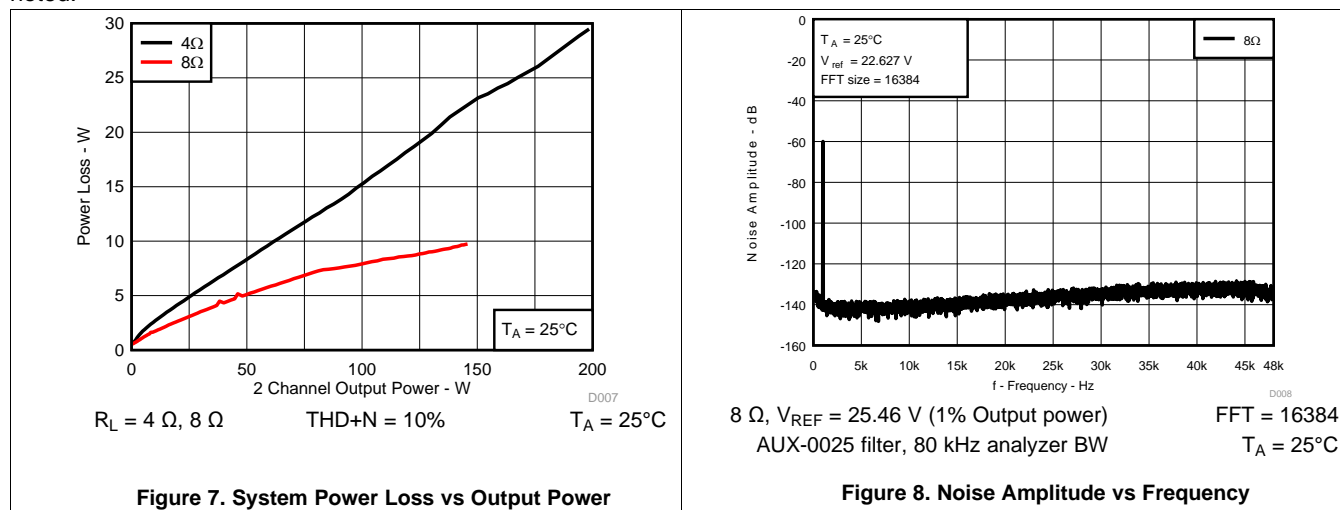


Figure 6. System Efficiency vs Output Power

**Typical Characteristics, BTL Configuration (continued)**

All Measurements taken at audio frequency = 1 kHz, PVDD\_X = 32 V, GVDD\_X = 12 V, R<sub>L</sub> = 8 Ω, f<sub>S</sub> = 450 kHz, R<sub>OC</sub> = 22 kΩ, T<sub>A</sub> = 25°C, Output Filter: L<sub>DEM</sub> = 10 μH, C<sub>DEM</sub> = 1 μF, mode = 00, AES17 + AUX-0025 measurement filters, unless otherwise noted.



### 7.10 Typical Characteristics, SE Configuration

All Measurements taken at audio frequency = 1 kHz, PVDD\_X = 32 V, GVDD\_X = 12 V, R<sub>L</sub> = 4 Ω, f<sub>S</sub> = 450 kHz, R<sub>OC</sub> = 22 kΩ, T<sub>A</sub> = 25°C, Output Filter: L<sub>DEM</sub> = 15 μH, C<sub>DEM</sub> = 680 nF, MODE = 11, AES17 + AUX-0025 measurement filters, unless otherwise noted.

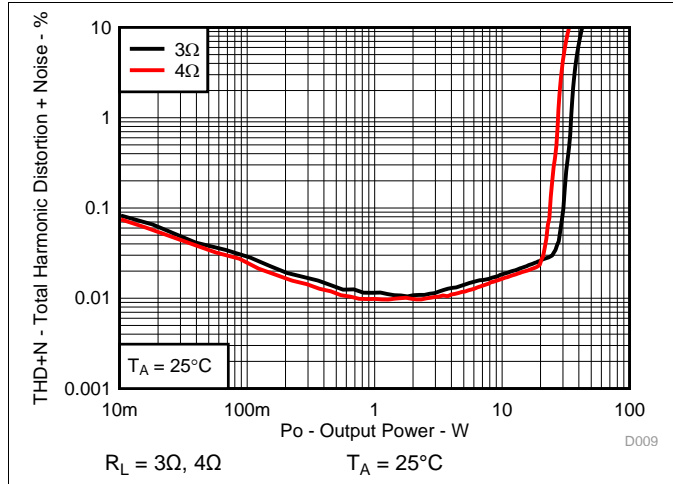


Figure 9. Total Harmonic Distortion+Noise vs Output Power

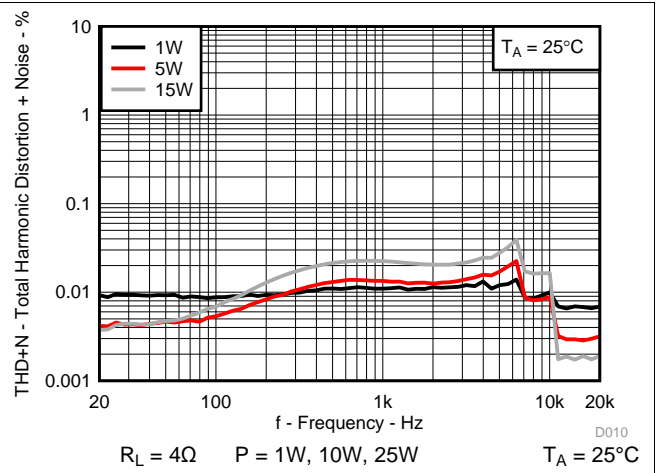


Figure 10. Total Harmonic Distortion+Noise vs Frequency

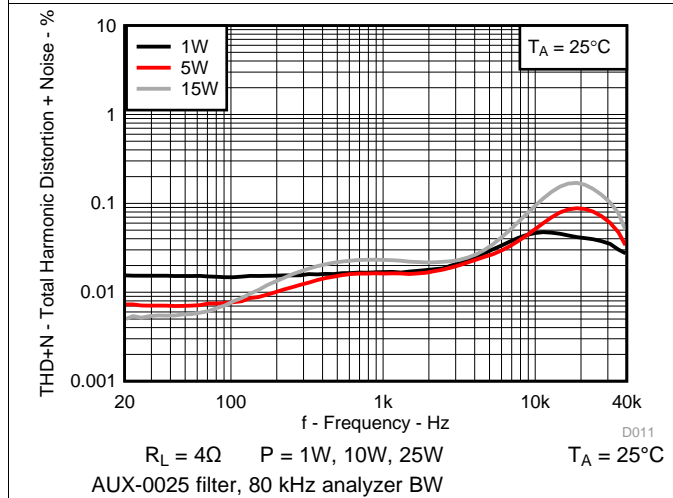


Figure 11. Total Harmonic Distortion+Noise vs Frequency

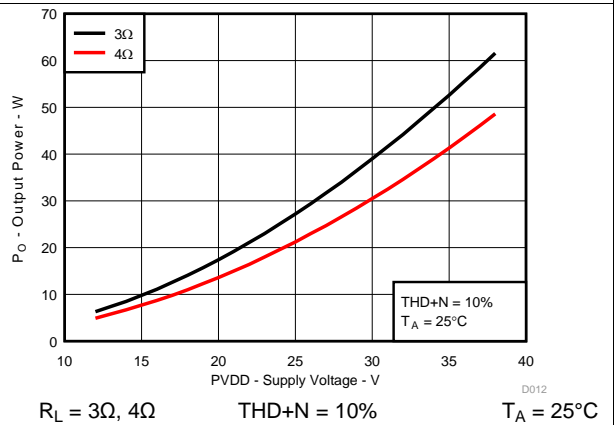


Figure 12. Output Power vs Supply Voltage

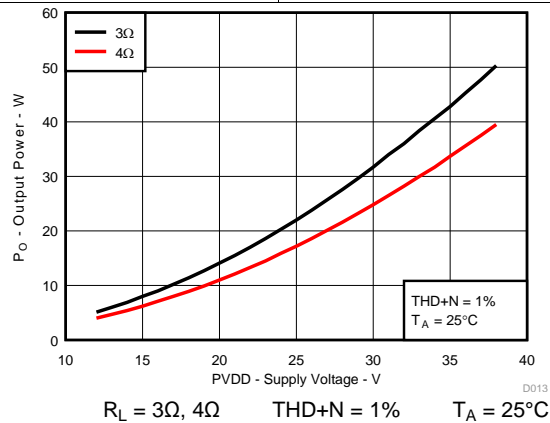


Figure 13. Output Power vs Supply Voltage

### 7.11 Typical Characteristics, PBTL Configuration

All Measurements taken at audio frequency = 1kHz, PVDD\_X = 32 V, GVDD\_X = 12 V, R<sub>L</sub> = 4Ω, f<sub>S</sub> = 450 kHz, R<sub>OC</sub> = 22 kΩ, T<sub>A</sub> = 25°C, Output Filter: L<sub>DEM</sub> = 10 μH, C<sub>DEM</sub> = 1 μF, MODE = 10, AES17 + AUX-0025 measurement filters, unless otherwise noted.

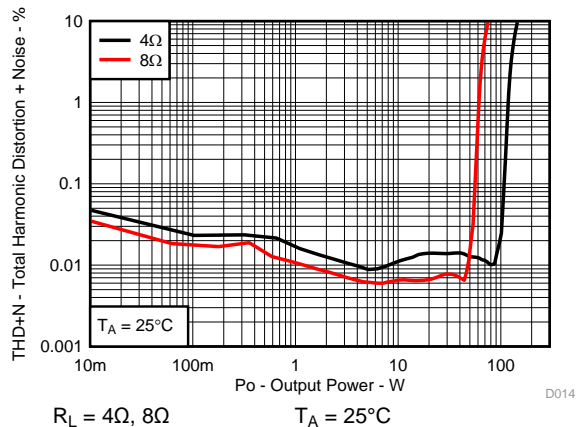


Figure 14. Total Harmonic Distortion+Noise vs Output Power

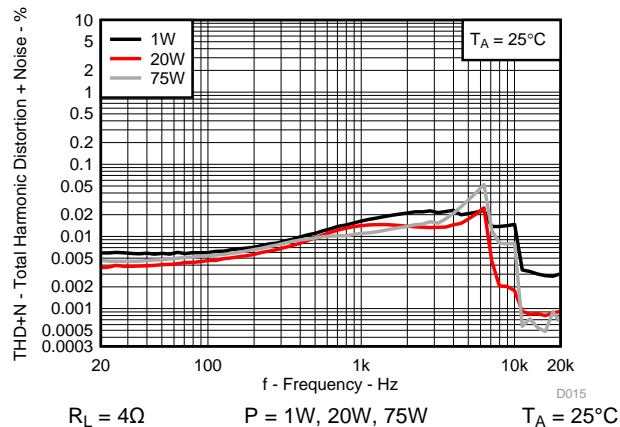


Figure 15. Total Harmonic Distortion+Noise vs Frequency

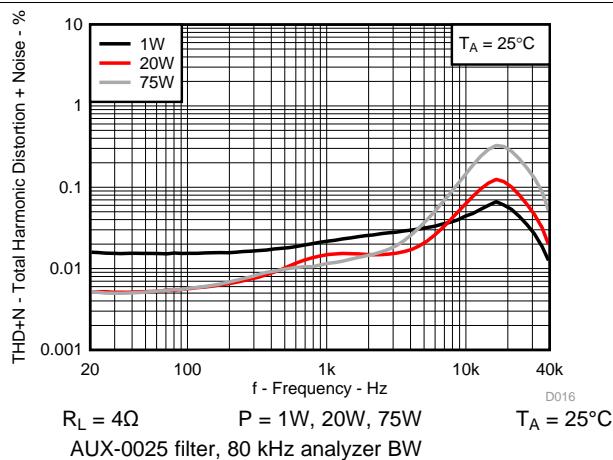


Figure 16. Total Harmonic Distortion+Noise vs Frequency

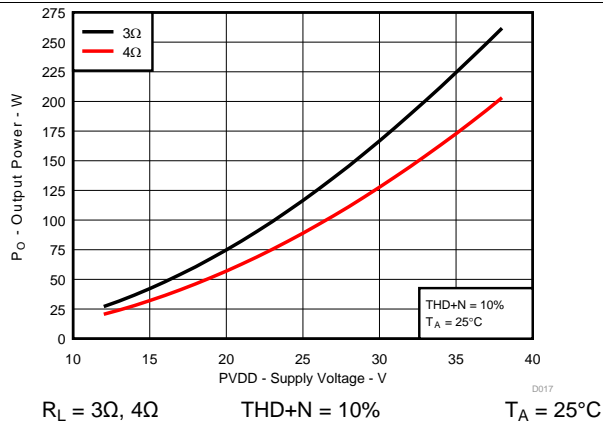


Figure 17. Output Power vs Supply Voltage

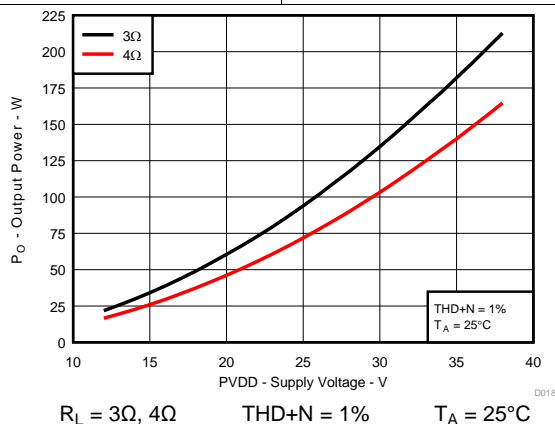


Figure 18. Output Power vs Supply Voltage

## 8 Parameter Measurement Information

All parameters are measured according to the conditions described in the [Recommended Operating Conditions](#), [Typical Characteristics](#), [BTL Configuration](#), [Typical Characteristics](#), [SE Configuration](#) and [Typical Characteristics](#), [PBTL Configuration](#) sections.

Most audio analyzers will not give correct readings of Class-D amplifiers' performance due to their sensitivity to out of band noise present at the amplifier output. AES-17 + AUX-0025 pre-analyzer filters are recommended to use for Class-D amplifier measurements. In absence of such filters, a 30-kHz low-pass filter (10  $\Omega$  + 47 nF) can be used to reduce the out of band noise remaining on the amplifier outputs.

## 9 Detailed Description

### 9.1 Overview

To facilitate system design, the TPA3250 needs only a 12-V supply in addition to the (typical) 32-V power-stage supply. An internal voltage regulator provides suitable voltage levels for the digital and low-voltage analog circuitry, AVDD and DVDD. Additionally, all circuitry requiring a floating voltage supply, that is, the high-side gate drive, is accommodated by built-in bootstrap circuitry requiring only an external capacitor for each half-bridge.

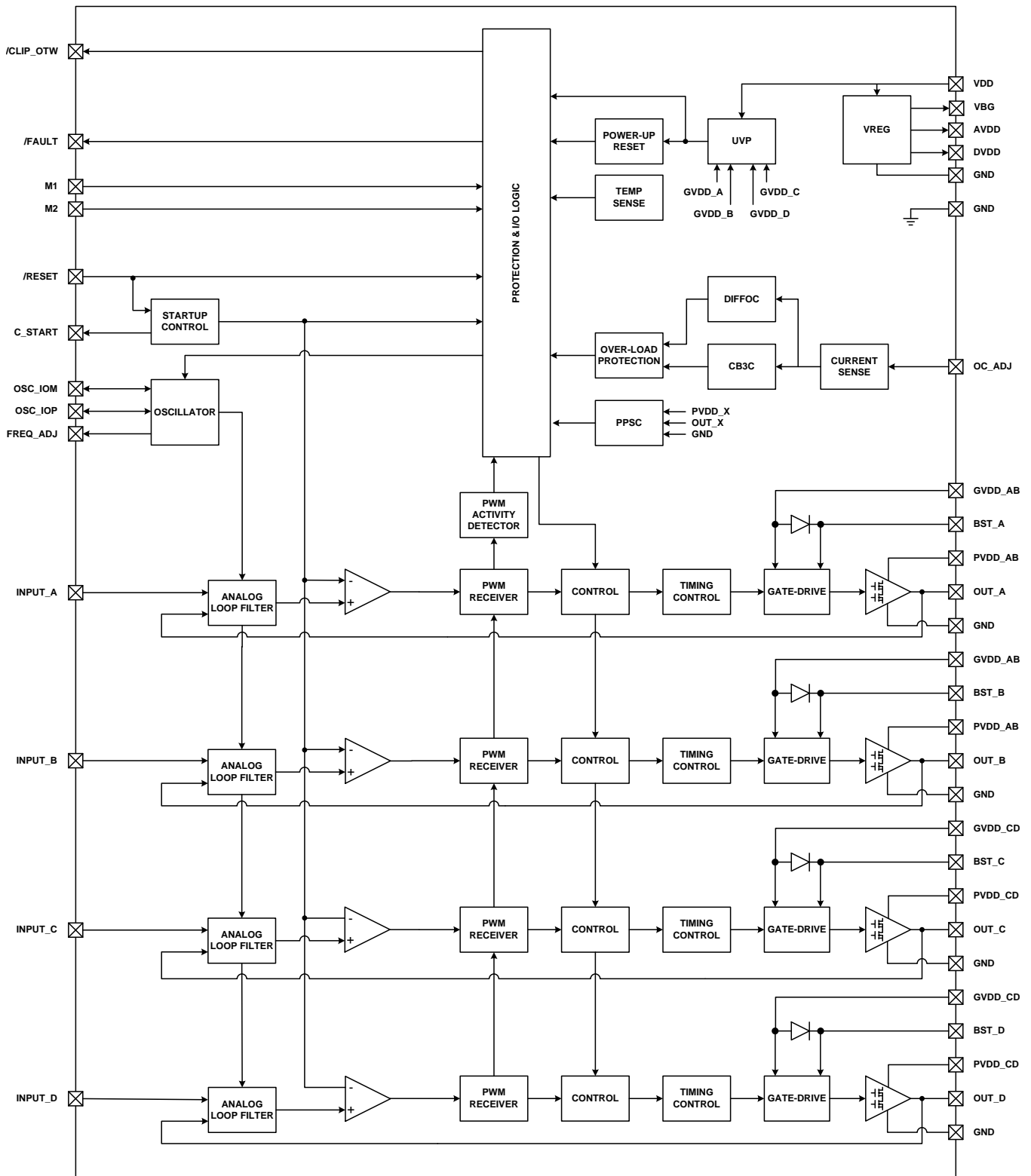
The audio signal path including gate drive and output stage is designed as identical, independent half-bridges. For this reason, each half-bridge has separate bootstrap pins (BST\_X). Power-stage supply pins (PVDD\_X) and gate drive supply pins (GVDD\_X) are separate for each full bridge. Although supplied from the same 12-V source, separating to GVDD\_AB, GVDD\_CD, and VDD on the printed-circuit board (PCB) by RC filters (see application diagram for details) is recommended. These RC filters provide the recommended high-frequency isolation. Special attention should be paid to placing all decoupling capacitors as close to their associated pins as possible. In general, the physical loop with the power supply pins, decoupling capacitors and GND return path to the device pins must be kept as short as possible and with as little area as possible to minimize induction (see reference board documentation for additional information).

For a properly functioning bootstrap circuit, a small ceramic capacitor must be connected from each bootstrap pin (BST\_X) to the power-stage output pin (OUT\_X). When the power-stage output is low, the bootstrap capacitor is charged through an internal diode connected between the gate-drive power-supply pin (GVDD\_X) and the bootstrap pins. When the power-stage output is high, the bootstrap capacitor potential is shifted above the output potential and thus provides a suitable voltage supply for the high-side gate driver. It is recommended to use 33-nF ceramic capacitors, size 0603 or 0805, for the bootstrap supply. These 33nF capacitors ensure sufficient energy storage, even during minimal PWM duty cycles, to keep the high-side power stage FET (LDMOS) fully turned on during the remaining part of the PWM cycle.

Special attention should be paid to the power-stage power supply; this includes component selection, PCB placement, and routing. As indicated, each full-bridge has independent power-stage supply pins (PVDD\_X). For optimal electrical performance, EMI compliance, and system reliability, it is important that each PVDD\_X node is decoupled with 1- $\mu$ F ceramic capacitor placed as close as possible to the supply pins. It is recommended to follow the PCB layout of the TPA3250 reference design. For additional information on recommended power supply and required components, see the application diagrams in this data sheet.

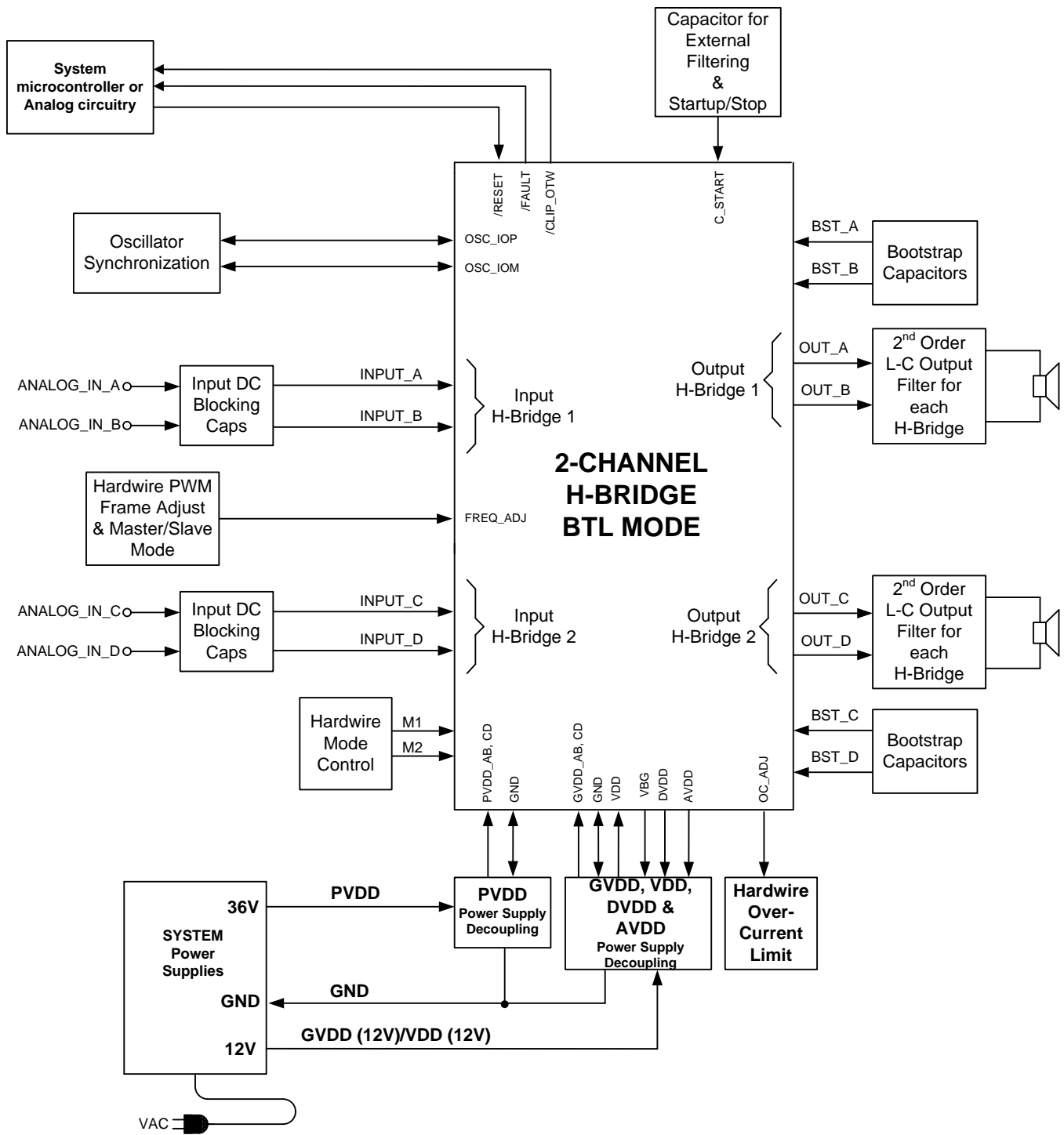
The 12-V supply should be from a low-noise, low-output-impedance voltage regulator. Likewise, the 36-V power-stage supply is assumed to have low output impedance and low noise. The power-supply sequence is not critical as facilitated by the internal power-on-reset circuit, but it is recommended to release **RESET** after the power supply is settled for minimum turn on audible artefacts. Moreover, the TPA3250 is fully protected against erroneous power-stage turn on due to parasitic gate charging. Thus, voltage-supply ramp rates (dV/dt) are non-critical within the specified range (see the [Recommended Operating Conditions](#) table of this data sheet).

## 9.2 Functional Block Diagrams



FunctionalBlockDiagram.vsd

Functional Block Diagrams (continued)



\*NOTE1: Logic AND in or outside microcontroller

Figure 19. System Block Diagram



## 9.3 Feature Description

### 9.3.1 Error Reporting

The  $\overline{\text{FAULT}}$ , and  $\overline{\text{CLIP\_OTW}}$ , pins are active-low, open-drain outputs. The function is for protection-mode signaling to a system-control device.

Any fault resulting in device shutdown is signaled by the  $\overline{\text{FAULT}}$  pin going low. Also,  $\overline{\text{CLIP\_OTW}}$  goes low when the device junction temperature exceeds 125°C (see [Table 2](#)).

**Table 2. Error Reporting**

$\overline{\text{FAULT}}$	$\overline{\text{CLIP\_OTW}}$	DESCRIPTION
0	0	Overtemperature (OTE) or overload (OLP) or undervoltage (UVP) Junction temperature higher than 125°C (overtemperature warning)
0	0	Overload (OLP) or undervoltage (UVP). Junction temperature higher than 125°C (overtemperature warning)
0	1	Overload (OLP) or undervoltage (UVP). Junction temperature lower than 125°C
1	0	Junction temperature higher than 125°C (overtemperature warning)
1	1	Junction temperature lower than 125°C and no OLP or UVP faults (normal operation)

Note that asserting either  $\overline{\text{RESET}}$  low forces the  $\overline{\text{FAULT}}$  signal high, independent of faults being present. TI recommends monitoring the  $\overline{\text{CLIP\_OTW}}$  signal using the system microcontroller and responding to an overtemperature warning signal by, that is, turning down the volume to prevent further heating of the device resulting in device shutdown (OTE).

To reduce external component count, an internal pullup resistor to 3.3 V is provided on both  $\overline{\text{FAULT}}$  and  $\overline{\text{CLIP\_OTW}}$  outputs.

## 9.4 Device Functional Modes

### 9.4.1 Device Protection System

The TPA3250 contains advanced protection circuitry carefully designed to facilitate system integration and ease of use, as well as to safeguard the device from permanent failure due to a wide range of fault conditions such as short circuits, overload, overtemperature, and undervoltage. The TPA3250 responds to a fault by immediately setting the power stage in a high-impedance (Hi-Z) state and asserting the  $\overline{\text{FAULT}}$  pin low. In situations other than overload and overtemperature error (OTE), the device automatically recovers when the fault condition has been removed, that is, the supply voltage has increased.

The device will function on errors, as shown in [Table 3](#).

**Table 3. Device Protection**

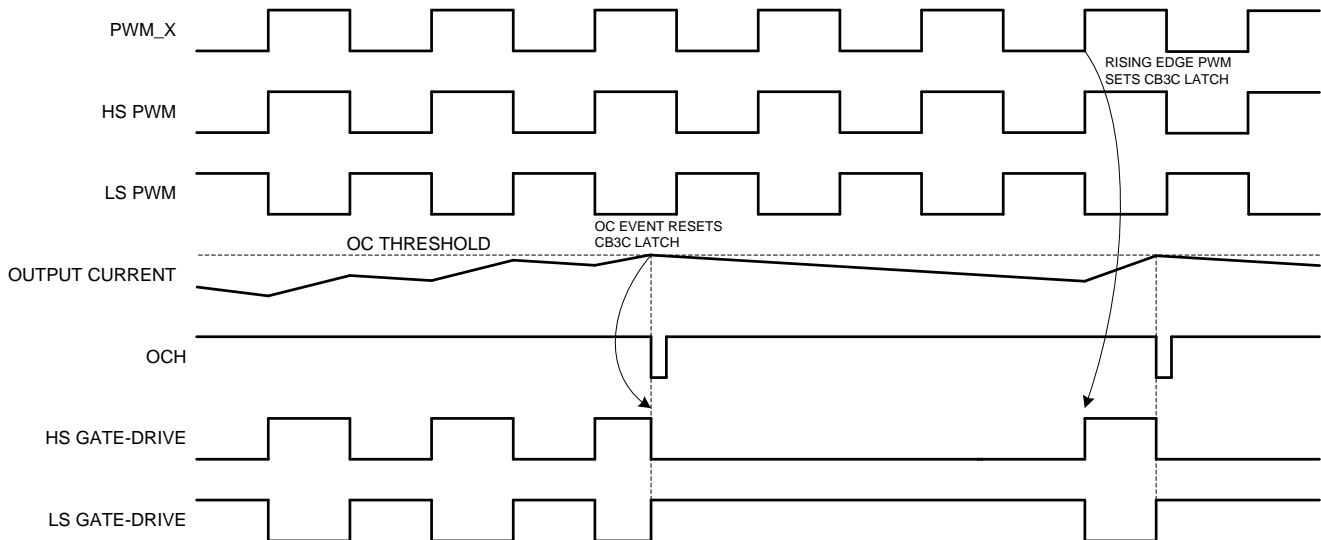
BTL	MODE	PBTL	MODE	SE	MODE
LOCAL ERROR IN	TURNS OFF	LOCAL ERROR IN	TURNS OFF	LOCAL ERROR IN	TURNS OFF
A	A+B	A	A+B+C+D	A	A+B
B		B		B	
C	C+D	C		C	C+D
D		D		D	

Bootstrap UVP does not shutdown according to the table, it shuts down the respective halfbridge (non-latching, does not assert  $\overline{\text{FAULT}}$ ).

#### 9.4.1.1 Overload and Short Circuit Current Protection

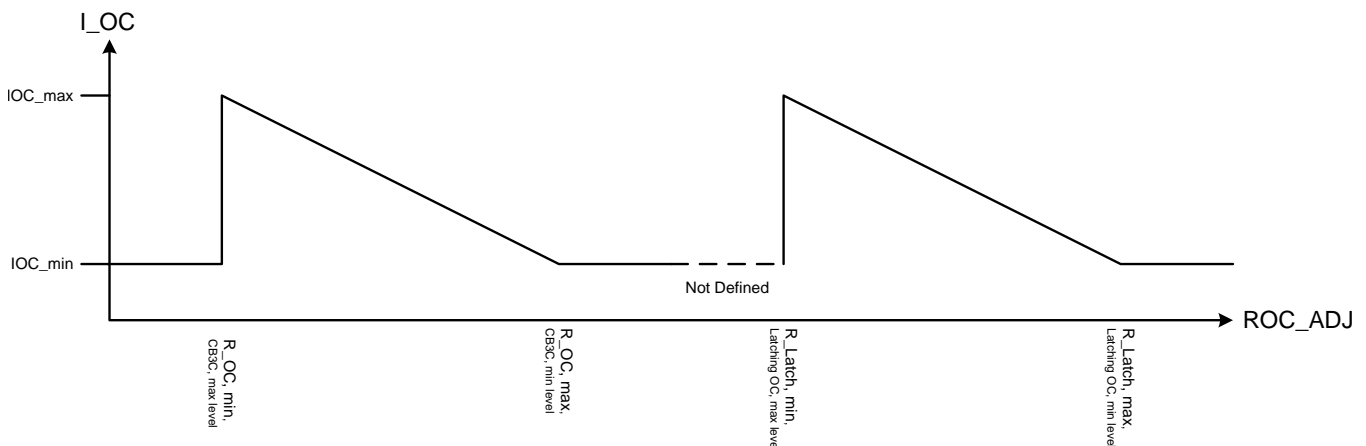
TPA3250 has fast reacting current sensors with a programmable trip threshold (OC threshold) on all high-side and low-side FETs. To prevent output current to increase beyond the programmed threshold, TPA3250 has the option of either limiting the output current for each switching cycle (Cycle By Cycle Current Control, CB3C) or to perform an immediate shutdown of the output in case of excess output current (Latching Shutdown). CB3C prevents premature shutdown due to high output current transients caused by high level music transients and a

drop of real speaker's load impedance, and allows the output current to be limited to a maximum programmed level. If the maximum output current persists, i.e. the power stage being overloaded with too low load impedance, the device will shut down the affected output channel and the affected output is put in a high-impedance (Hi-Z) state until a RESET cycle is initiated. CB3C works individually for each half bridge output. If an over current event is triggered, CB3C performs a state flip of the half bridge output that is cleared upon beginning of next PWM frame.



**Figure 20. CB3C Timing Example**

During CB3C an over load counter increments for each over current event and decrease for each non-over current PWM cycle. This allows full amplitude transients into a low speaker impedance without a shutdown protection action. In the event of a short circuit condition, the over current protection limits the output current by the CB3C operation and eventually shut down the affected output if the overload counter reaches its maximum value. If a latched OC operation is required such that the device shuts down the affected output immediately upon first detected over current event, this protection mode should be selected. The over current threshold and mode (CB3C or Latched OC) is programmed by the OC\_ADJ resistor value. The OC\_ADJ resistor needs to be within its intentional value range for either CB3C operation or Latched OC operation.



**Figure 21. OC Threshold versus OC\_ADJ Resistor Value Example**

OC\_ADJ values outside specified value range for either CB3C or latched OC operation will result in minimum OC threshold.

**Table 4. Device Protection**

OC_ADJ Resistor Value	Protection Mode	OC Threshold
22kΩ	CB3C	16.3A
24kΩ	CB3C	15.1A
27kΩ	CB3C	13.5A
30kΩ	CB3C	12.3A
47kΩ	Latched OC	16.3A
51kΩ	Latched OC	15.1A
56kΩ	Latched OC	13.5A
64kΩ	Latched OC	12.3A

#### 9.4.1.2 DC Speaker Protection

The output DC protection scheme protects a connected speaker from excess DC current caused by a speaker wire accidentally shorted to chassis ground. Such a short circuit results in a DC voltage of  $PVDD/2$  across the speaker, which potentially can result in destructive current levels. The output DC protection detects any unbalance of the output and input current of a BTL output, and in the event of the unbalance exceeding a programmed threshold, the overload counter increments until its maximum value and the affected output channel is shut down. DC Speaker Protection is disabled in PBTL and SE mode operation.

#### 9.4.1.3 Pin-to-Pin Short Circuit Protection (PPSC)

The PPSC detection system protects the device from permanent damage in the case that a power output pin (OUT\_X) is shorted to GND\_X or PVDD\_X. For comparison, the OC protection system detects an overcurrent after the demodulation filter where PPSC detects shorts directly at the pin before the filter. PPSC detection is performed at startup that is, when VDD is supplied, consequently a short to either GND\_X or PVDD\_X after system startup does not activate the PPSC detection system. When PPSC detection is activated by a short on the output, all half bridges are kept in a Hi-Z state until the short is removed; the device then continues the startup sequence and starts switching. The detection is controlled globally by a two step sequence. The first step ensures that there are no shorts from OUT\_X to GND\_X, the second step tests that there are no shorts from OUT\_X to PVDD\_X. The total duration of this process is roughly proportional to the capacitance of the output LC filter. The typical duration is  $< 15 \text{ ms}/\mu\text{F}$ . While the PPSC detection is in progress, FAULT is kept low, and the device will not react to changes applied to the RESET pin. If no shorts are present the PPSC detection passes, and FAULT is released. A device reset will not start a new PPSC detection. PPSC detection is enabled in BTL and PBTL output configurations, the detection is not performed in SE mode. To make sure not to trip the PPSC detection system it is recommended not to insert a resistive load to GND\_X or PVDD\_X.

#### 9.4.1.4 Overtemperature Protection OTW and OTE

TPA3250 has a two-level temperature-protection system that asserts an active-low warning signal (CLIP\_OTW) when the device junction temperature exceeds 125°C (typical) and, if the device junction temperature exceeds 155°C (typical), the device is put into thermal shutdown, resulting in all half-bridge outputs being set in the high-impedance (Hi-Z) state and FAULT being asserted low. OTE is latched in this case. To clear the OTE latch, RESET must be asserted. Thereafter, the device resumes normal operation.

#### 9.4.1.5 Undervoltage Protection (UVP) and Power-on Reset (POR)

The UVP and POR circuits of the TPA3250 fully protect the device in any power-up/down and brownout situation. While powering up, the POR circuit resets the overload circuit (OLP) and ensures that all circuits are fully operational when the GVDD\_X and VDD supply voltages reach stated in the [Electrical Characteristics](#) table. Although GVDD\_X and VDD are independently monitored, a supply voltage drop below the UVP threshold on any VDD or GVDD\_X pin results in all half-bridge outputs immediately being set in the high-impedance (Hi-Z) state and FAULT being asserted low. The device automatically resumes operation when all supply voltages have increased above the UVP threshold.

### 9.4.1.6 Fault Handling

If a fault situation occurs while in operation, the device acts accordingly to the fault being a global or a channel fault. A global fault is a chip-wide fault situation and causes all PWM activity of the device to be shut down, and will assert FAULT low. A global fault is a latching fault and clearing FAULT and restart operation requires resetting the device by toggling RESET. Toggling RESET should never be allowed with excessive system temperature, so it is advised to monitor RESET by a system microcontroller and only allow releasing RESET (RESET high) if the OTW signal is cleared (high). A channel fault results in shutdown of the PWM activity of the affected channel(s). Note that asserting RESET low forces the FAULT signal high, independent of faults being present. TI recommends monitoring the OTW signal using the system micro controller and responding to an over temperature warning signal by, that is, turning down the volume to prevent further heating of the device resulting in device shutdown (OTE).

**Table 5. Error Reporting**

Fault/Event	Fault/Event Description	Global or Channel	Reporting Method	Latched/Self Clearing	Action needed to Clear	Output FETs
PVDD_X UVP	Voltage Fault	Global	$\overline{\text{FAULT}}$ pin	Self Clearing	Increase affected supply voltage	HI-Z
VDD UVP						
AVDD UVP						
POR (DVDD UVP)	Power On Reset	Global	$\overline{\text{FAULT}}$ pin	Self Clearing	Allow DVDD to rise	HI-Z
BST_X UVP	Voltage Fault	Channel (Half Bridge)	None	Self Clearing	Allow BST cap to recharge (lowside ON, VDD 12V)	HighSide off
OTW	Thermal Warning	Global	$\overline{\text{OTW}}$ pin	Self Clearing	Cool below OTW threshold	Normal operation
OTE	Thermal Shutdown	Global	$\overline{\text{FAULT}}$ pin	Latched	Toggle $\overline{\text{RESET}}$	HI-Z
OLP (CB3C>1.7ms)	OC Shutdown	Channel	$\overline{\text{FAULT}}$ pin	Latched	Toggle $\overline{\text{RESET}}$	HI-Z
Latched OC (47k $\Omega$ <ROC_ADJ<68 k $\Omega$ )	OC Shutdown	Channel	$\overline{\text{FAULT}}$ pin	Latched	Toggle $\overline{\text{RESET}}$	HI-Z
CB3C (22k $\Omega$ <ROC_ADJ<30 k $\Omega$ )	OC Limiting	Channel	None	Self Clearing	Reduce signal level or remove short	Flip state, cycle by cycle at fs/3
Stuck at Fault <sup>(1)</sup>	No OSC_IO activity in Slave Mode	Global	None	Self Clearing	Resume OSC_IO activity	HI-Z

(1) Stuck at Fault occurs when input OSC\_IO input signal frequency drops below minimum frequency given in the [Electrical Characteristics](#) table of this data sheet.

### 9.4.1.7 Device Reset

Asserting  $\overline{\text{RESET}}$  low initiates the device ramp down. The output FETs go into a Hi-Z state after the ramp down is complete. Output pull downs are active both in SE mode and BTL mode with  $\overline{\text{RESET}}$  low.

In BTL modes, to accommodate bootstrap charging prior to switching start, asserting the reset input low enables weak pulldown of the half-bridge outputs.

Asserting reset input low removes any fault information to be signaled on the  $\overline{\text{FAULT}}$  output, that is,  $\overline{\text{FAULT}}$  is forced high. A rising-edge transition on reset input allows the device to resume operation after an overload fault. To ensure thermal reliability, the rising edge of reset must occur no sooner than 4 ms after the falling edge of  $\overline{\text{FAULT}}$ .

## 10 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 10.1 Application Information

TPA3250 can be configured either in stereo BTL mode, 4 channel SE mode, mono PBTL mode, or in 2.1 mixed 1x BTL + 2x SE mode depending on output power conditions and system design.

### 10.2 Typical Applications

#### 10.2.1 Stereo BTL Application

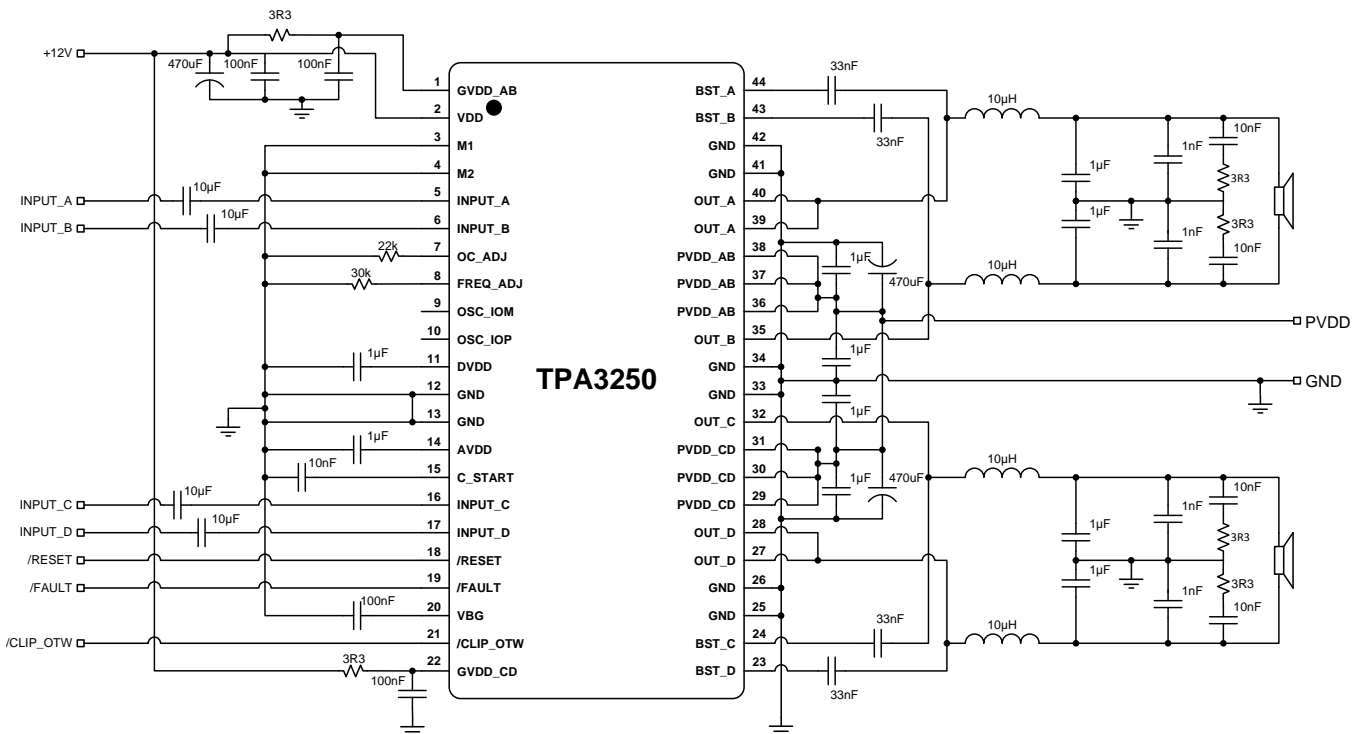


Figure 22. Typical Differential Input BTL Application

## Typical Applications (continued)

### 10.2.1.1 Design Requirements

For this design example, use the parameters in [Table 6](#).

**Table 6. Design Requirements, BTL Application**

DESIGN PARAMETER	EXAMPLE
Low Power (Pull-up) Supply	3.3 V
Mid Power Supply 12 V	12 V
High Power Supply	12 - 32 V
Mode Selection	M2 = L
	M1 = L
Analog Inputs	INPUT_A = $\pm 3.9$ V (peak, max)
	INPUT_B = $\pm 3.9$ V (peak, max)
	INPUT_C = $\pm 3.9$ V (peak, max)
	INPUT_D = $\pm 3.9$ V (peak, max)
Output Filters	Inductor-Capacitor Low Pass Filter (10 $\mu$ H + 1 $\mu$ F)
Speaker Impedance	3-8 $\Omega$

### 10.2.1.2 Detailed Design Procedures

A rising-edge transition on reset input allows the device to execute the startup sequence and starts switching.

The CLIP signal is indicating that the output is approaching clipping. The signal can be used to either an audio volume decrease or intelligent power supply nominally operating at a low rail adjusting to a higher supply rail.

The device is inverting the audio signal from input to output.

The DVDD and AVDD pins are not recommended to be used as a voltage sources for external circuitry.

#### 10.2.1.2.1 Decoupling Capacitor Recommendations

In order to design an amplifier that has robust performance, passes regulatory requirements, and exhibits good audio performance, good quality decoupling capacitors should be used. In practice, X7R should be used in this application.

The voltage of the decoupling capacitors should be selected in accordance with good design practices. Temperature, ripple current, and voltage overshoot must be considered. This fact is particularly true in the selection of the 1 $\mu$ F that is placed on the power supply to each full-bridge. It must withstand the voltage overshoot of the PWM switching, the heat generated by the amplifier during high power output, and the ripple current created by high power output. A minimum voltage rating of 50 V is required for use with a 32V power supply.

#### 10.2.1.2.2 PVDD Capacitor Recommendation

The large capacitors used in conjunction with each full-bridge, are referred to as the PVDD Capacitors. These capacitors should be selected for proper voltage margin and adequate capacitance to support the power requirements. In practice, with a well designed system power supply, 1000  $\mu$ F, 50 V supports most applications. The PVDD capacitors should be low ESR type because they are used in a circuit associated with high-speed switching.

#### 10.2.1.2.3 PCB Material Recommendation

FR-4 Glass Epoxy material with 2 oz. (70  $\mu$ m) copper is recommended for use with the TPA3250. The use of this material can provide for higher power output, improved thermal performance, and better EMI margin (due to lower PCB trace inductance).

#### 10.2.1.2.4 Oscillator

The oscillator frequency can be trimmed by external control of the `FREQ_ADJ` pin.

To reduce interference problems while using radio receiver tuned within the AM band, the switching frequency can be changed from nominal to lower values. These values should be chosen such that the nominal and the lower value switching frequencies together results in the fewest cases of interference throughout the AM band. The oscillator frequency can be selected by the value of the `FREQ_ADJ` resistor connected to GND in master mode according to the description in the Recommended Operating Conditions table.

For slave mode operation, turn off the oscillator by pulling the `FREQ_ADJ` pin to DVDD. This configures the `OSC_I/O` pins as inputs to be slaved from an external differential clock. In a master/slave system inter channel delay is automatically setup between the switching of the audio channels, which can be illustrated by no idle channels switching at the same time. This will not influence the audio output, but only the switch timing to minimize noise coupling between audio channels through the power supply to optimize audio performance and to get better operating conditions for the power supply. The inter channel delay will be setup for a slave device depending on the polarity of the `OSC_I/O` connection such that a slave mode 1 is selected by connecting the master device `OSC_I/O` to the slave 1 device `OSC_I/O` with same polarity (+ to + and - to -), and slave mode 2 is selected with the inverse polarity (+ to - and - to +).

### 10.2.2 Application Curves

Relevant performance plots for TPA3250 in BTL configuration are shown in [Typical Characteristics](#), [BTL Configuration](#)

**Table 7. Relevant Performance Plots, BTL Configuration**

PLOT TITLE	FIGURE NUMBER
Total Harmonic Distortion+Noise vs Frequency	<a href="#">Figure 1</a>
Total Harmonic Distortion+Noise vs Frequency, 80kHz analyzer BW	<a href="#">Figure 2</a>
Total Harmonic Distortion + Noise vs Output Power	<a href="#">Figure 3</a>
Output Power vs Supply Voltage, 10% THD+N	<a href="#">Figure 4</a>
Output Power vs Supply Voltage, 10% THD+N	<a href="#">Figure 6</a>
System Efficiency vs Output Power	<a href="#">Figure 6</a>
System Power Loss vs Output Power	<a href="#">Figure 7</a>
Output Power vs Case Temperature	
Noise Amplitude vs Frequency	<a href="#">Figure 8</a>

### 10.2.3 Typical Application, Single Ended (1N) SE

TPA3250 can be configured either in stereo BTL mode, 4 channel SE mode, mono PBTL mode, or in 2.1 mixed 1x BTL + 2x SE mode depending on output power conditions and system design.

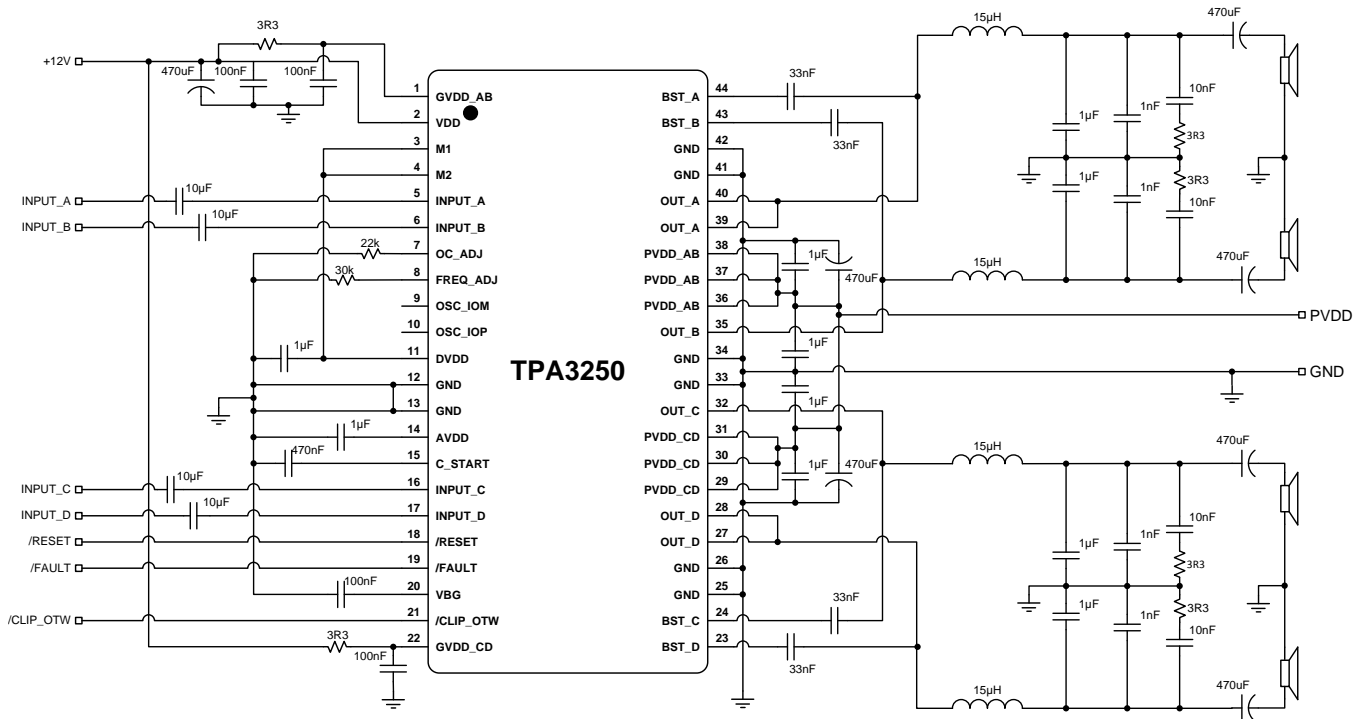


Figure 23. Typical Single Ended (1N) SE Application

#### 10.2.3.1 Design Requirements

Refer to [Stereo BTL Application](#) for the Design Requirements.

Table 8. Design Requirements, SE Application

DESIGN PARAMETER	EXAMPLE
Low Power (Pull-up) Supply	3.3 V
Mid Power Supply 1 2V	12 V
High Power Supply	12 - 32 V
Mode Selection	M2 = H
	M1 = H
Analog Inputs	INPUT_A = ±3.9 V (peak, max)
	INPUT_B = ±3.9 V (peak, max)
	INPUT_C = ±3.9 V (peak, max)
	INPUT_D = ±3.9 V (peak, max)
Output Filters	Inductor-Capacitor Low Pass Filter (15 µH + 680 nF)
Speaker Impedance	2 - 8 Ω

#### 10.2.3.2 Detailed Design Procedures

Refer to [Stereo BTL Application](#) for the Detailed Design Procedures.



### 10.2.3.3 Application Curves

Relevant performance plots for TPA3250 in PBTL configuration are shown in [Typical Characteristics](#), [SE Configuration](#)

**Table 9. Relevant Performance Plots, SE Configuration**

PLOT TITLE	FIGURE NUMBER
Total Harmonic Distortion+Noise vs Output Power	<a href="#">Figure 9</a>
Total Harmonic Distortion+Noise vs Frequency	<a href="#">Figure 10</a>
Total Harmonic Distortion+Noise vs Frequency, 80kHz analyzer BW	<a href="#">Figure 11</a>
Output Power vs Supply Voltage, 10% THD+N	<a href="#">Figure 12</a>
Output Power vs Supply Voltage, 1% THD+N	<a href="#">Figure 13</a>
Output Power vs Case Temperature	

### 10.2.4 Typical Application, Differential (2N) PBTL

TPA3250 can be configured either in stereo BTL mode, 4 channel SE mode, mono PBTL mode, or in 2.1 mixed 1x BTL + 2x SE mode depending on output power conditions and system design.

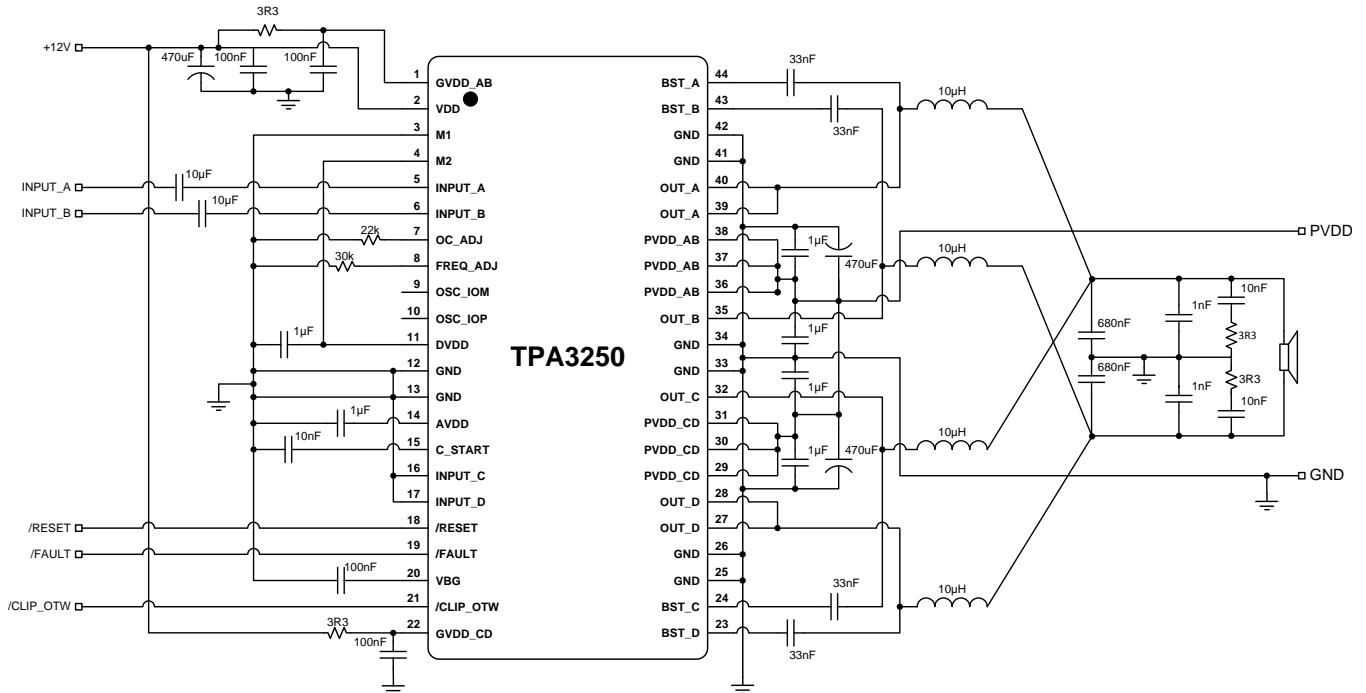


Figure 24. Typical Differential (2N) PBTL Application

#### 10.2.4.1 Design Requirements

Refer to [Stereo BTL Application](#) for the Design Requirements.

Table 10. Design Requirements, PBTL Application

DESIGN PARAMETER	EXAMPLE
Low Power (Pull-up) Supply	3.3 V
Mid Power Supply 12 V	12 V
High Power Supply	12 - 32 V
Mode Selection	M2 = H
	M1 = L
Analog Inputs	INPUT_A = ±3.9V (peak, max)
	INPUT_B = ±3.9V (peak, max)
	INPUT_C = Grounded
	INPUT_D = Grounded
Output Filters	Inductor-Capacitor Low Pass Filter (10 μH + 1 μF)
Speaker Impedance	2 - 4 Ω

#### 10.2.4.2 Detailed Design Procedures

Refer to [Stereo BTL Application](#) for the Detailed Design Procedures.

### 10.2.4.3 Application Curves

Relevant performance plots for TPA3250 in PBTL configuration are shown in [Typical Characteristics](#), [PBTL Configuration](#)

**Table 11. Relevant Performance Plots, PBTL Configuration**

PLOT TITLE	FIGURE NUMBER
Total Harmonic Distortion+Noise vs Output Power	<a href="#">Figure 14</a>
Total Harmonic Distortion+Noise vs Frequency	<a href="#">Figure 15</a>
Total Harmonic Distortion+Noise vs Frequency, 80kHz analyzer BW	<a href="#">Figure 16</a>
Output Power vs Supply Voltage, 10% THD+N	<a href="#">Figure 17</a>
Output Power vs Supply Voltage, 1% THD+N	<a href="#">Figure 18</a>
Output Power vs Case Temperature	

## 11 Power Supply Recommendations

### 11.1 Power Supplies

The TPA3250 device requires two external power supplies for proper operation. A high-voltage supply called PVDD is required to power the output stage of the speaker amplifier and its associated circuitry. Additionally, one mid-voltage power supply for GVDD\_X and VDD is required to power the gate-drive and other internal digital and analog portions of the device. The allowable voltage range for both the PVDD and the GVDD\_X/VDD supplies are listed in the [Recommended Operating Conditions](#) table. Ensure both the PVDD and the GVDD\_X/VDD supplies can deliver more current than listed in the [Electrical Characteristics](#) table.

#### 11.1.1 VDD Supply

The VDD supply required from the system is used to power several portions of the device. It provides power to internal regulators DVDD and AVDD that are used to power digital and analog sections of the device, respectively. Proper connection, routing, and decoupling techniques are highlighted in the TPA3250 device EVM User's Guide [SLVUAG8](#) (as well as the [Application Information](#) section and [Layout Examples](#) section) and must be followed as closely as possible for proper operation and performance. Deviation from the guidance offered in the TPA3250 device EVM User's Guide, which followed the same techniques as those shown in the [Application Information](#) section, may result in reduced performance, errant functionality, or even damage to the TPA3250 device. Some portions of the device also require a separate power supply which is a lower voltage than the VDD supply. To simplify the power supply requirements for the system, the TPA3250 device includes integrated low-dropout (LDO) linear regulators to create these supplies. These linear regulators are internally connected to the VDD supply and their outputs are presented on AVDD and DVDD pins, providing a connection point for an external bypass capacitors. It is important to note that the linear regulators integrated in the device have only been designed to support the current requirements of the internal circuitry, and should not be used to power any additional external circuitry. Additional loading on these pins could cause the voltage to sag and increase noise injection, which negatively affects the performance and operation of the device.

#### 11.1.2 GVDD\_X Supply

The GVDD\_X supply required from the system is used to power the gate-drives for the output H-bridges. Proper connection, routing, and decoupling techniques are highlighted in the TPA3250 device EVM User's Guide [SLVUAG8](#) (as well as the [Application Information](#) section and [Layout Examples](#) section) and must be followed as closely as possible for proper operation and performance. Deviation from the guidance offered in the TPA3250 device EVM User's Guide, which followed the same techniques as those shown in the [Application Information](#) section, may result in reduced performance, errant functionality, or even damage to the TPA3250 device.

#### 11.1.3 PVDD Supply

The output stage of the speaker amplifier drives the load using the PVDD supply. This is the power supply which provides the drive current to the load during playback. Proper connection, routing, and decoupling techniques are highlighted in the TPA3250 device EVM User's Guide [SLVUAG8](#) (as well as the [Application Information](#) section and [Layout Examples](#) section) and must be followed as closely as possible for proper operation and performance. Due the high-voltage switching of the output stage, it is particularly important to properly decouple the output power stages in the manner described in the TPA3250 device EVM User's Guide [SLVUAG8](#). The lack of proper decoupling, like that shown in the EVM User's Guide, can results in voltage spikes which can damage the device, or cause poor audio performance and device shutdown faults.

### 11.2 Powering Up

The TPA3250 does not require a power-up sequence, but it is recommended to hold  $\overline{\text{RESET}}$  low minimum 400ms after PVDD supply voltage is turned ON. The outputs of the H-bridges remain in a high-impedance state until the gate-drive supply voltage (GVDD\_X) and VDD voltage are above the undervoltage protection (UVP) voltage threshold (see the [Electrical Characteristics](#) table of this data sheet). This allows an internal circuit to charge the external bootstrap capacitors by enabling a weak pulldown of the half-bridge output as well as initiating a controlled ramp up sequence of the output voltage.

Powering Up (continued)

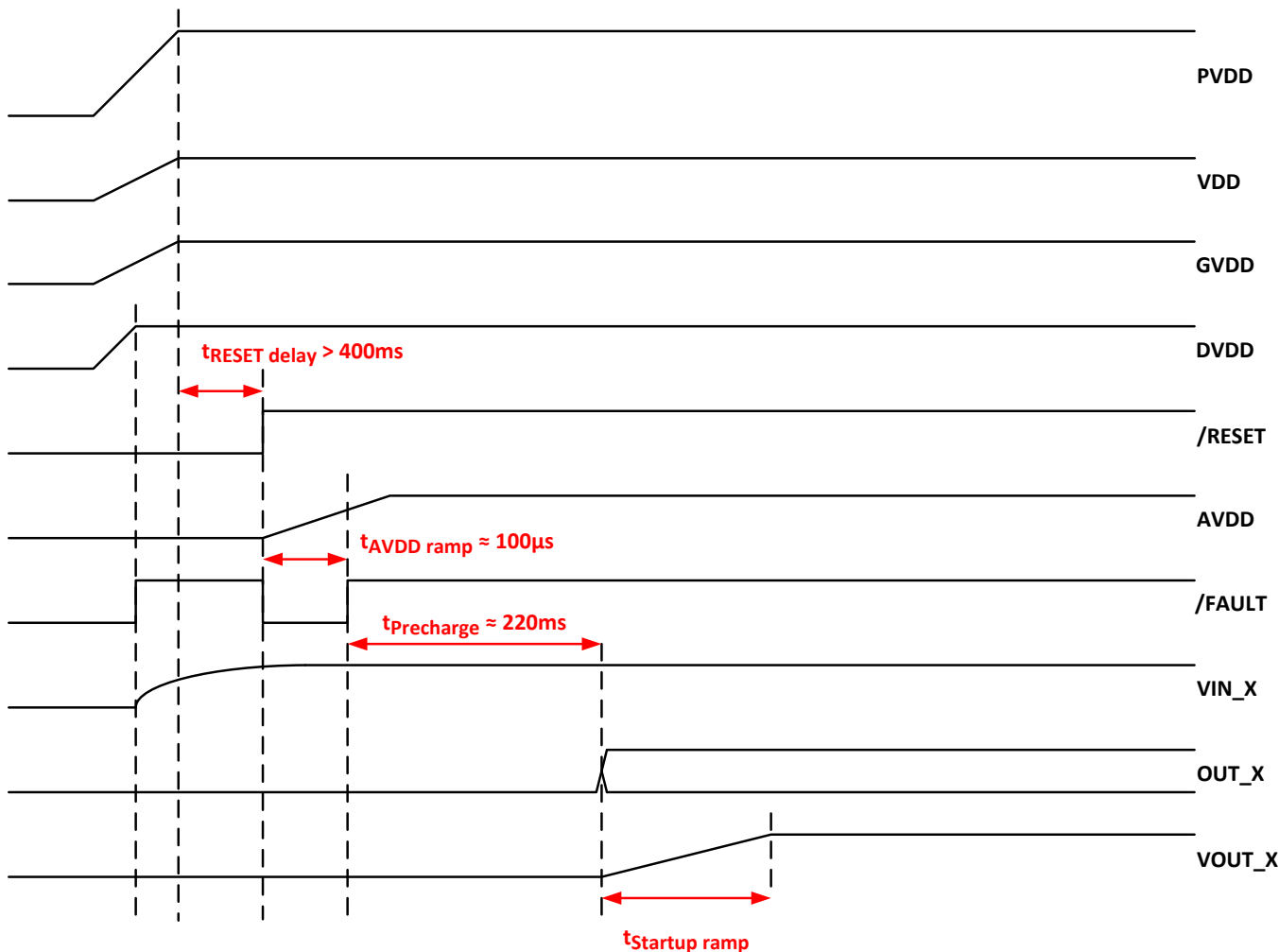


Figure 25. Startup Timing

When  $\overline{RESET}$  is released to turn on TPA3250,  $\overline{FAULT}$  signal will turn low and AVDD voltage regulator will be enabled.  $\overline{FAULT}$  will stay low until AVDD reaches the undervoltage protection (UVP) voltage threshold (see the Electrical Characteristics table of this data sheet). After a precharge time to stabilize the DC voltage across the input AC coupling capacitors, before the ramp up sequence starts.

11.3 Powering Down

The TPA3250 does not require a power-down sequence. The device remains fully operational as long as the gate-drive supply (GVDD\_X) voltage and VDD voltage are above the undervoltage protection (UVP) voltage threshold (see the [Electrical Characteristics](#) table of this data sheet). Although not specifically required, it is a good practice to hold RESET low during power down, thus preventing audible artifacts including pops or clicks by initiating a controlled ramp down sequence of the output voltage.

## 11.4 Thermal Design

### 11.4.1 Thermal Performance

TPA3250 thermal performance is dependent on the thermal design of the PCB. As a result, the maximum continuous output power attainable will be influenced by the PCB design. The continuous power rating is lower than the peak output power capability of the device. TPA3250 peak power rating is based on the burst capability of the device. The peak to average power ratio of TPA3250 is well suited to handle even demanding audio playback without thermal shutdown. Thermal performance with typical audio content (burst) versus sine wave content (continuous) should be considered when defining the thermal test requirements for the end product.

### 11.4.2 Thermal Performance with Continuous Output Power

It is recommended to operate TPA3250 below the OTW threshold, which in most systems will require the average output power to be below the maximum peak output power. The maximum continuous power TPA3250 will deliver depends directly on the thermal design of the PCB and for the entire system (closed box with no air flow, or a fanned system etc.). Thermal performance is also impacted by PVDD voltage and switching frequency. The best configuration for a given application will often depend on the continuous output power requirements.

**Table 12. Device and PCB Temperatures with 8-Ω Load, T<sub>A</sub> = 40°C**

T <sub>A</sub> = 40°C, TPA3250 EVM, No Airflow. Steady State Temperatures.						
PVDD	Switching Frequency	Continuous Power [W]		Device Top Temperature	Maximum PCB Temperature	Comment
32V	450kHz	73W	10% THD	114°C	89°C	
32V	450kHz	18W	1/4 of 10% THD power	87°C	71°C	
32V	450kHz	9W	1/8 of 10% THD power	77°C	65°C	
32V	600kHz	72W	10% THD	128°C	98°C	OTW after 236 seconds
32V	600kHz	18W	1/4 of 10% THD power	105°C	84°C	
32V	600kHz	9W	1/8 of 10% THD power	85°C	70°C	
36V	450kHz	92W	10% THD	150°C	113°C	OTW after 95 seconds
36V	450kHz	23W	1/4 of 10% THD power	111°C	87°C	
36V	450kHz	11.5W	1/8 of 10% THD power	79°C	71°C	
36V	600kHz	91W	10% THD	OTE <sup>(1)</sup>		OTW after 3 seconds. Not recommended.
36V	600kHz	22.5W	1/4 of 10% THD power	144°C	109°C	OTW after 152 seconds
36V	600kHz	11.5W	1/8 of 10% THD power	115°C	90°C	

(1) Steady state data is not available because device heats up to OTE in this condition.

**Table 13. Device and PCB Temperatures with 4-Ω Load, T<sub>A</sub> = 40°C**

T <sub>A</sub> = 40°C, TPA3250 EVM, No Airflow. Steady State Temperatures.						
PVDD	Switching Frequency	Continuous Power [W]		Device Top Temperature	Maximum PCB Temperature	Comment
32V	450kHz	130W	10% THD	OTE		OTW after 1 second. Not recommended.
32V	450kHz	32.5W	1/4 of 10% THD power	147°C	111°C	OTW after 92 seconds. Not recommended.
32V	450kHz	16W	1/8 of 10% THD power	107°C	85°C	
32V	600kHz	130W	10% THD	OTE <sup>(1)</sup>		OTW after 1 second. Not recommended.
32V	600kHz	32.5W	1/4 of 10% THD power	OTE <sup>(1)</sup>		OTW after 29 seconds. Not recommended.
32V	600kHz	16W	1/8 of 10% THD power	147°C	99°C	OTW after 92 seconds. Not recommended.
36V	450kHz	165W	10% THD	OTE <sup>(1)</sup>		OTW after 0 seconds. Not recommended.
36V	450kHz	41W	1/4 of 10% THD power	OTE <sup>(1)</sup>		OTW after 11 seconds. Not recommended.

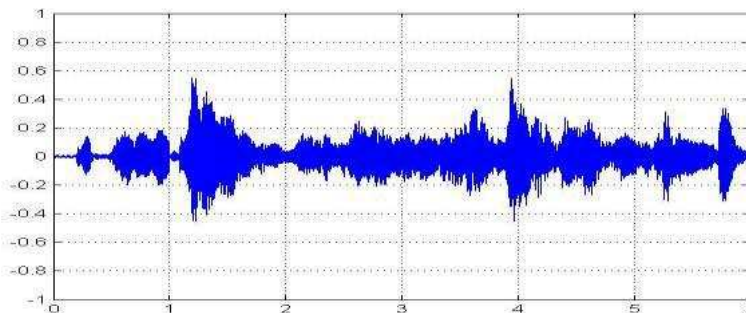
(1) Steady state data is not available because device heats up to OTE in this condition.

**Table 13. Device and PCB Temperatures with 4-Ω Load, T<sub>A</sub> = 40°C (continued)**

T <sub>A</sub> = 40°C, TPA3250 EVM, No Airflow. Steady State Temperatures.						
36V	450kHz	21W	1/8 of 10% THD power	142°C	108°C	OTW after 134 seconds. Not recommended.
36V	600kHz	Not recommended				

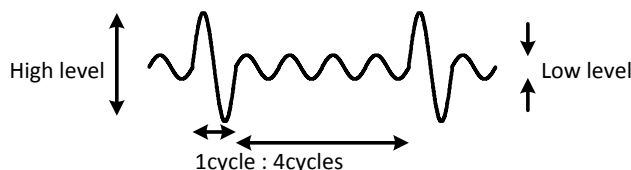
**11.4.3 Thermal Performance with Non-Continuous Output Power**

As audio signals often have a peak to average ratio larger than one (average level below maximum peak output), the thermal performance for audio signals can be illustrated using burst signals with different burst ratios.



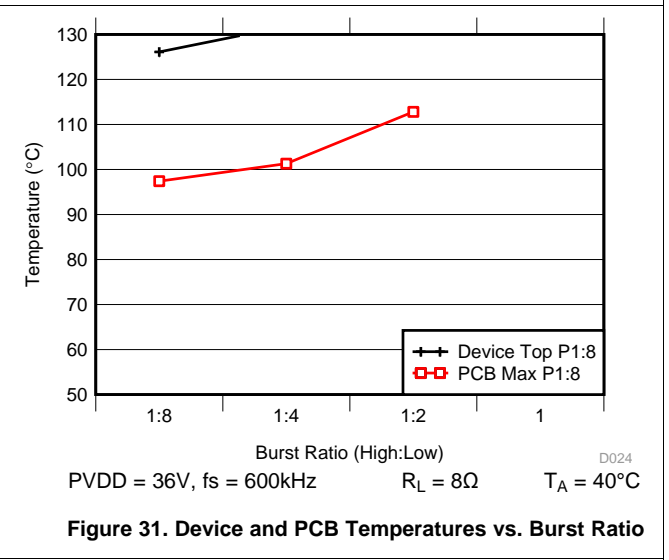
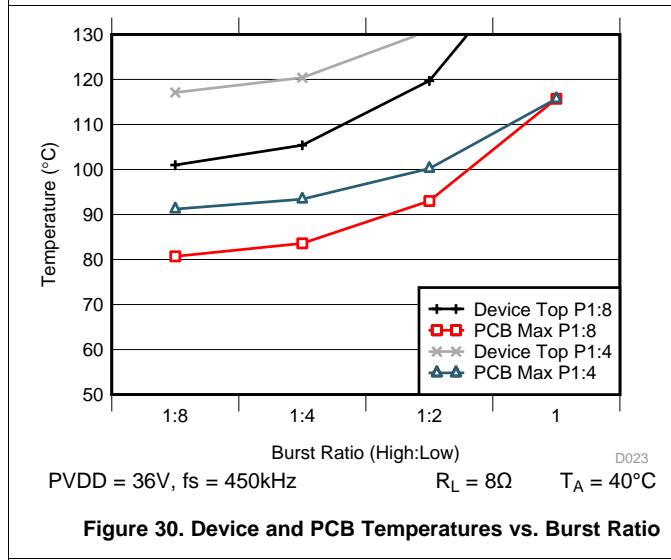
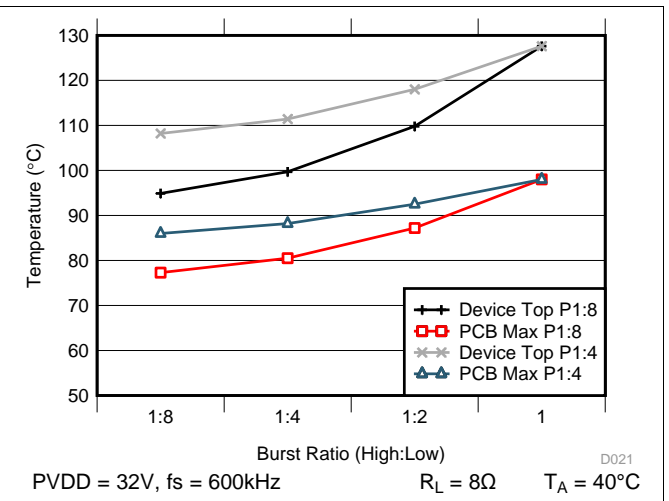
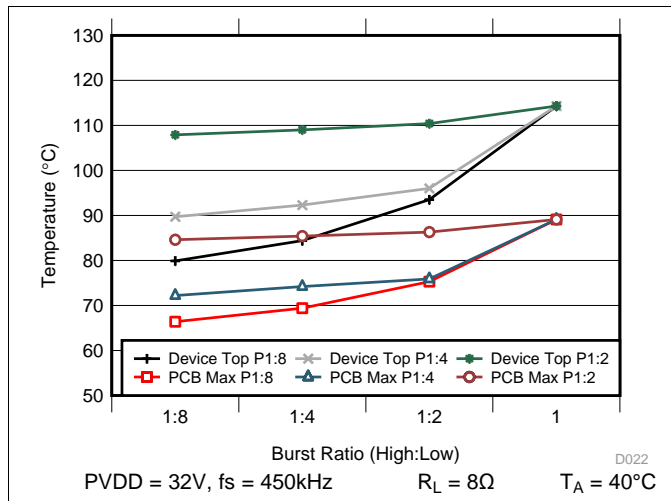
**Figure 26. Example of audio signal**

A burst signal is characterized by the high-level to low-level ratio as well as the duration of the high level and low level, e.g. a burst 1:4 stimuli is a single period of high level followed by 4 cycles of low level.



**Figure 27. Example of 1:4 Burst Signal**

The following analysis of thermal performance for TPA3250 is made with the TPA3250 EVM surrounded by still air (no airflow) with a controlled air temperature of 40°C. For 32-V operation the system is not thermally limited with 8Ω load, but depending on the burst stimuli for operation at 36V some thermal limitations may occur, depending on switching frequency and average to maximum power ratio. Low to maximum power ratio of the burst stimuli is given in the plots as for example P1:8 which equals 1 cycle of full power followed by 8 cycles of low power.





## 12 Layout

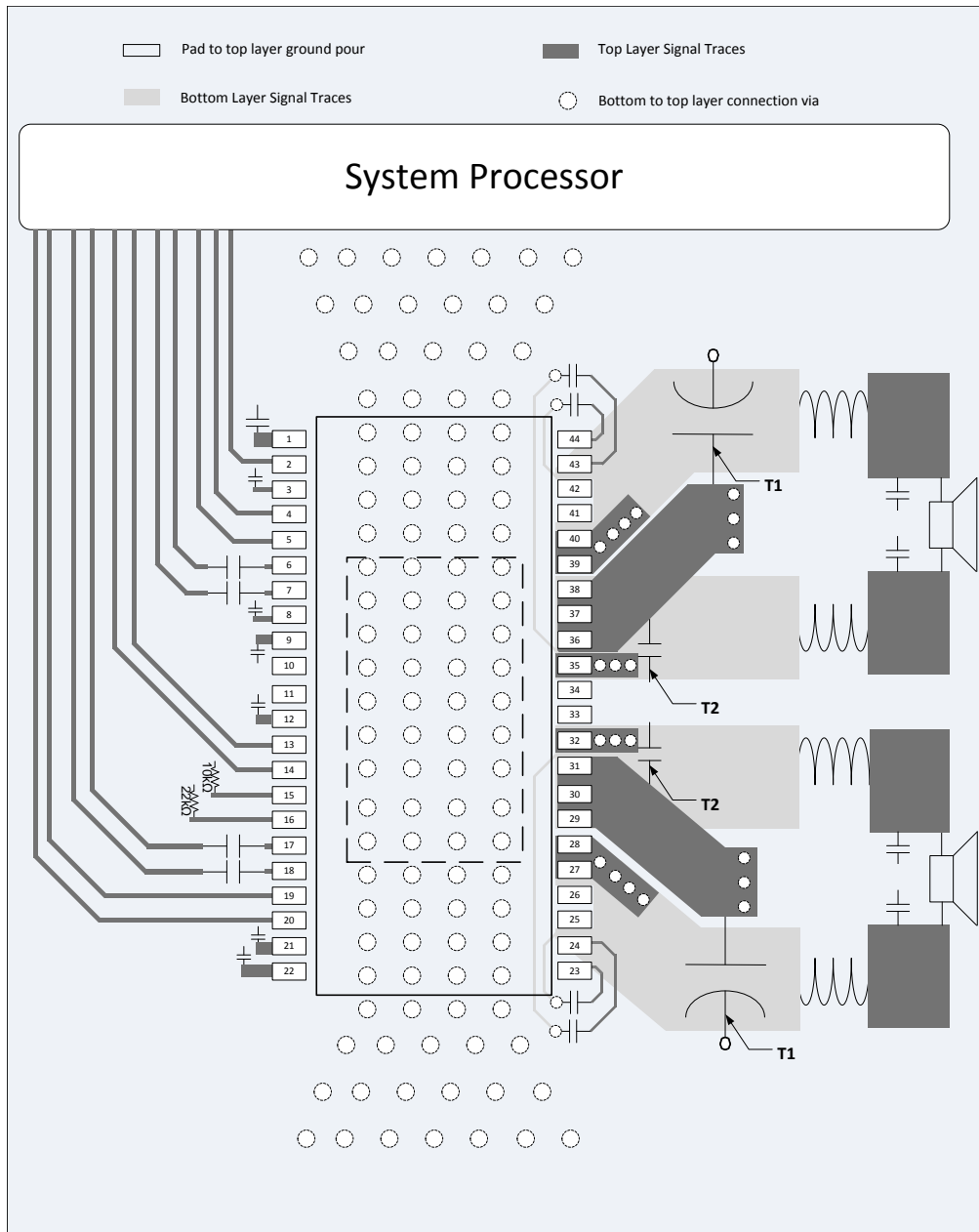
### 12.1 Layout Guidelines

- Use an unbroken ground plane to have good low impedance and inductance return path to the power supply for power and audio signals.
- Maintain a contiguous ground plane from the ground pins to the PCB area surrounding the device for as many of the ground pins as possible, since the ground pins are the best conductors of heat in the package.
- PCB layout, audio performance and EMI are linked closely together.
- Routing the audio input should be kept short and together with the accompanied audio source ground.
- The small bypass capacitors on the PVDD lines of the DUT be placed as close the PVDD pins as possible.
- A local ground area underneath the device is important to keep solid to minimize ground bounce.
- Orient the passive component so that the narrow end of the passive component is facing the TPA3250 device, unless the area between two pads of a passive component is large enough to allow copper to flow in between the two pads.
- Avoid placing other heat producing components or structures near the TPA3250 device.
- Avoid cutting off the flow of heat from the TPA3250 device to the surrounding ground areas with traces or via strings, especially on output side of device.

Netlist for this printed circuit board is generated from the schematic in [Figure 32](#).

## 12.2 Layout Examples

### 12.2.1 BTL Application Printed Circuit Board Layout Example

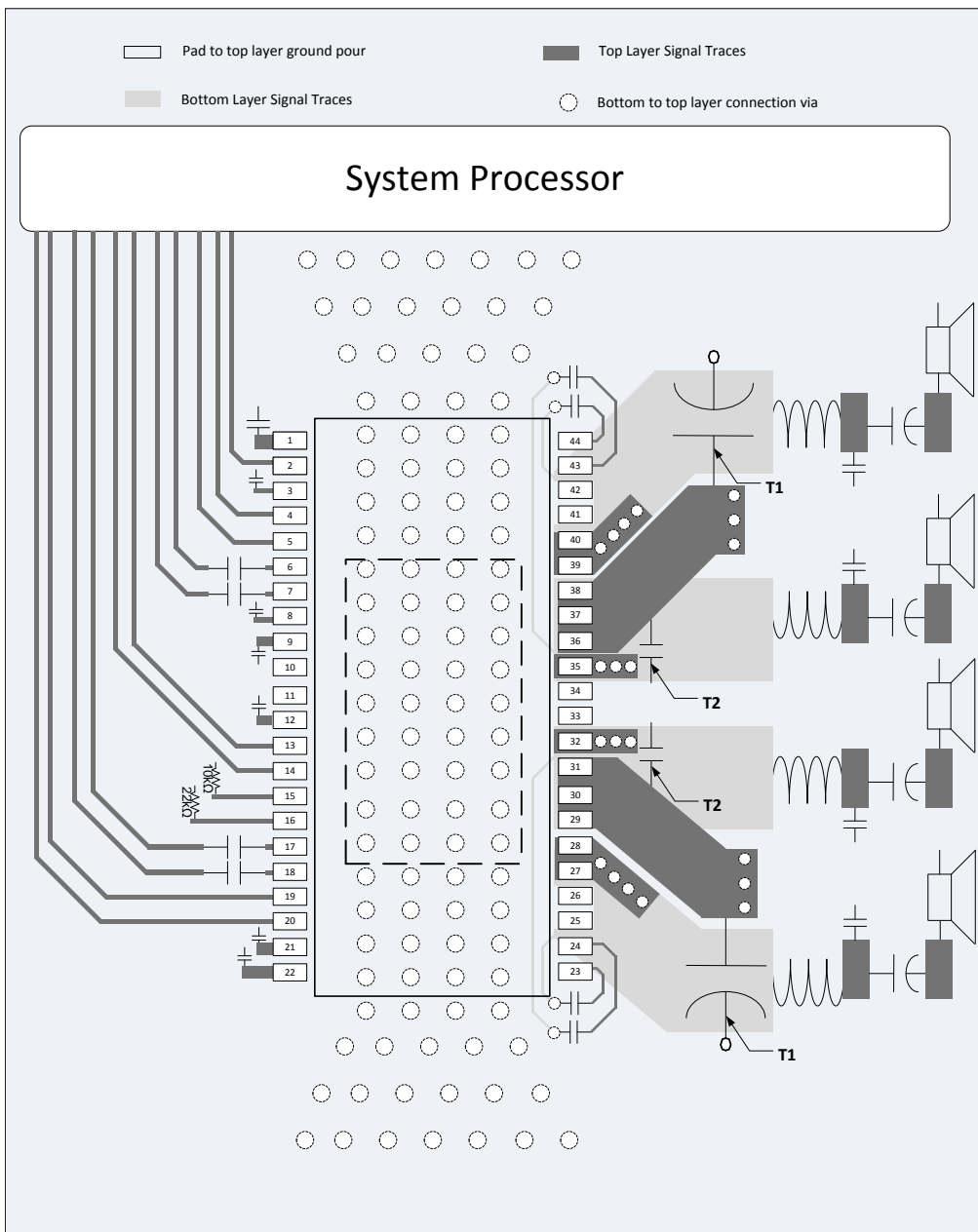


- A. Note: PCB layout example shows composite layout. Dark grey: Top layer copper traces, light gray: Bottom layer copper traces. All PCB area not used for traces should be GND copper pour (transparent on example image)
- B. **Note T1:** PVDD decoupling bulk capacitors should be as close as possible to the PVDD and GND\_X pins. Wide traces should be routed on the top layer with direct connection to the pins and without going through vias. No vias or traces should be blocking the current path.
- C. **Note T2:** Close decoupling of PVDD with low impedance X7R ceramic capacitors placed close to the pins.
- D. **Note T3:** PowerPad™ needs to be soldered to PCB GND copper pour

**Figure 32. BTL Application Printed Circuit Board - Composite**

Layout Examples (continued)

12.2.2 SE Application Printed Circuit Board Layout Example

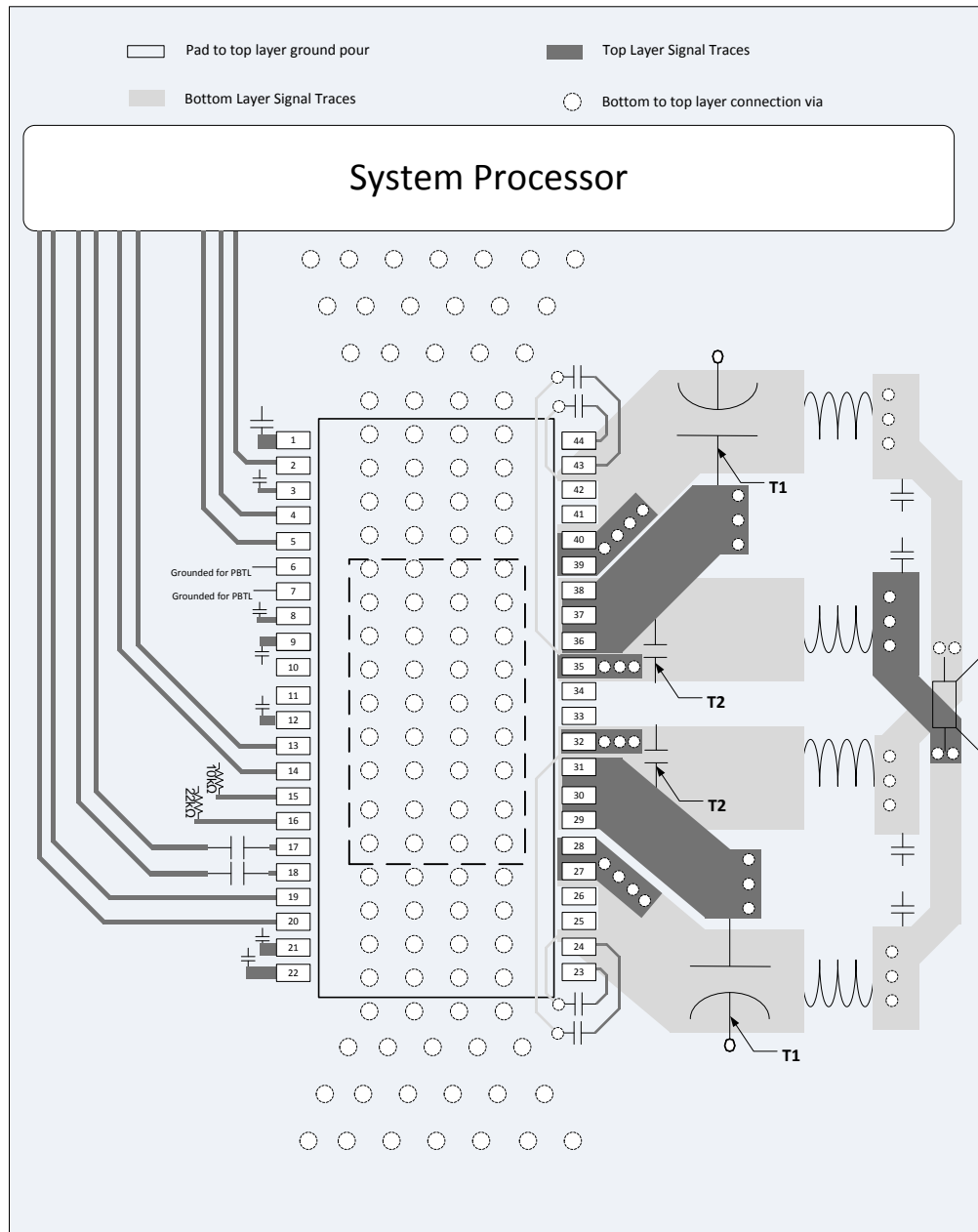


- A. Note: PCB layout example shows composite layout. Dark grey: Top layer copper traces, light gray: Bottom layer copper traces. All PCB area not used for traces should be GND copper pour (transparent on example image)
- B. **Note T1:** PVDD decoupling bulk capacitors should be as close as possible to the PVDD and GND\_X pins. Wide traces should be routed on the top layer with direct connection to the pins and without going through vias. No vias or traces should be blocking the current path.
- C. **Note T2:** Close decoupling of PVDD with low impedance X7R ceramic capacitors is placed close to the pins.
- D. **Note T3:** PowerPad™ needs to be soldered to PCB GND copper pour

Figure 33. SE Application Printed Circuit Board - Composite

## Layout Examples (continued)

### 12.2.3 PBTL Application Printed Circuit Board Layout Example



- A. Note: PCB layout example shows composite layout. Dark grey: Top layer copper traces, light gray: Bottom layer copper traces. All PCB area not used for traces should be GND copper pour (transparent on example image)
- B. **Note T1:** PVDD decoupling bulk capacitors should be as close as possible to the PVDD and GND\_X pins. Wide traces should be routed on the top layer with direct connection to the pins and without going through vias. No vias or traces should be blocking the current path.
- C. **Note T2:** Close decoupling of PVDD with low impedance X7R ceramic capacitors is placed close to the pins.
- D. **Note T3:** PowerPad™ needs to be soldered to PCB GND copper pour

**Figure 34. PBTL Application Printed Circuit Board - Composite**

## 13 器件和文档支持

### 13.1 文档支持

《TPA3250D2EVM 用户指南》，[SLVUAG8](#)

### 13.2 社区资源

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](#), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 13.3 商标

PurePath, PowerPAD, E2E are trademarks of Texas Instruments.

蓝光光盘 is a trademark of Blu-ray Disc Association.

All other trademarks are the property of their respective owners.

### 13.4 静电放电警告



这些装置包含有限的内置 ESD 保护。存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

### 13.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 14 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

## PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">TPA3250D2DDW</a>	Active	Production	HTSSOP (DDW)   44	35   TUBE	Yes	NIPDAU	Level-3-260C-168 HR	0 to 70	3250
TPA3250D2DDW.A	Active	Production	HTSSOP (DDW)   44	35   TUBE	Yes	NIPDAU	Level-3-260C-168 HR	0 to 70	3250
TPA3250D2DDW.B	Active	Production	HTSSOP (DDW)   44	35   TUBE	Yes	NIPDAU	Level-3-260C-168 HR	0 to 70	3250
<a href="#">TPA3250D2DDWR</a>	Active	Production	HTSSOP (DDW)   44	2000   LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	0 to 70	3250
TPA3250D2DDWR.A	Active	Production	HTSSOP (DDW)   44	2000   LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	0 to 70	3250
TPA3250D2DDWR.B	Active	Production	HTSSOP (DDW)   44	2000   LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	0 to 70	3250

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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## GENERIC PACKAGE VIEW

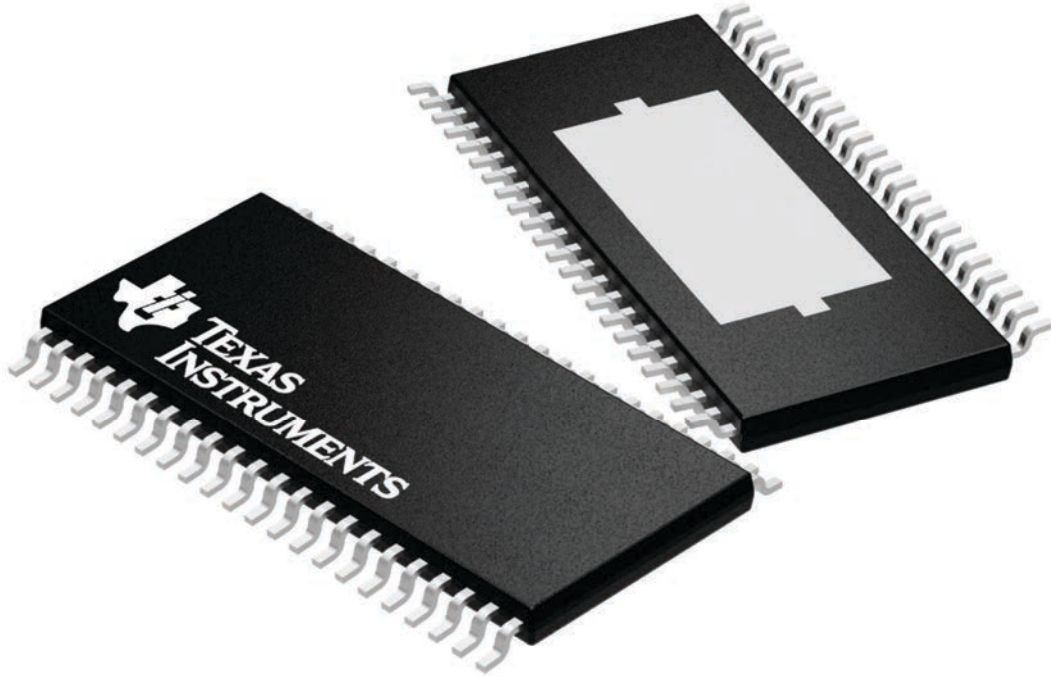
**DDW 44**

**PowerPAD TSSOP - 1.2 mm max height**

6.1 x 14, 0.635 mm pitch

PLASTIC SMALL OUTLINE

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4224876/A



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